PALEONTOLOGY.—Argyrotheca gardnerae, *new name.*[1] C. WYTHE COOKE, U. S. Geological Survey.

As the name I applied to a new brachiopod in 1919 proves to be preoccupied, I here propose the new name *Argyrotheca gardnerae.* The specific name is in recognition of the paleontologic researches of Miss Julia Gardner.

Argyrotheca gardnerae Cooke, new name

Argyrotheca dalli Cooke, Carnegie Inst. Washington Pub. 291: 152, *pl. 16, figs. 5a–c.* 1919.

not *Argyrotheca dalli* Aldrich Bull. Am. Pal. 5: 13, *pl. 5, figs. 9–10.* 1911.

Occurrence: St. Bartholomew, B. W. I.

Geologic horizon: Upper Eocene.

Type: U. S. National Museum, No. 167201.

PALEONTOLOGY.—Nanicella, *a new genus of Devonian Foraminifera*[2]. LLOYD G. HENBEST, U. S. Geological Survey. (Communicated by JOHN B. REESIDE, JR.)

Through the kindness of Prof. A. K. Miller, University of Iowa, an opportunity was offered in 1932 for studying the type specimens of *Endothyra gallowayi* Thomas (Journal of Paleontology 5: 40. 1931). A close study of the specimens confirmed a notion that I had held for some time that *E. gallowayi* belongs to a new genus, but inasmuch as the preservation of the type specimens is hardly adequate for determining the shell features with any degree of confidence, it seemed best to wait for better material. Recently, Mrs. F. B. Plummer, University of Texas, very generously shared her rich collection of topotypical material with me, and it now seems appropriate to introduce the generic name *Nanicella* for the form represented by *E. gallowayi* Thomas, which species accordingly becomes the genotype.

The name *Nanicella* refers to the reduced shape and size of the chambers in their subordination to the general architecture of the shell (Latin *nanus,* dwarf, +*cella,* chamber). In this respect, *Nanicella* resembles *Orobias, Nummulostegina,* and *Staffella* somewhat more than *Endothyra.* In external form it resembles *Orobias* most closely, but differs significantly from that genus by being more discoid and less involute and having a chamber morphology that is less completely subordinated to the general plan of the shell. In comparison

[1] Published by permission of the Director of the U. S. Geological Survey. Received November 15, 1934.

[2] Published by permission of the Director, U. S. Geological Survey. Received December 4, 1934.

with *Endothyra, Nanicella* is considerably more advanced in regard to the degree of chamber subordination, although our present records indicate an earlier existence for *Nanicella. Endothyra* as represented particularly by *E. bowmani,* the genotype, exhibits several so-called primitive traits not possessed by *Nanicella* in that it is irregularly coiled, its chambers have a somewhat spherical form, and a distinct boundary between the spiral and septal walls is absent.

Work is under way to make a detailed study of the shell structure.

BOTANY.—Sabal louisiana, *the correct name for the polymorphic palmetto of Louisiana.*[1] MIRIAM L. BOMHARD, U. S. Forest Service. (Communicated by E. P. KILLIP.)

Palmettos have always been and are today a conspicuous and familiar part of the Louisiana landscape, especially in the Mississippi Valley. Accounts of early travels through Louisiana show that most of the travelers were profoundly impressed by the vegetation, and mention is frequently made of the palmettos as well as of the large cypress trees, the magnolias, the great vines, and the native cane.

As early as two and a half centuries ago, Le Clercq, in his account of La Salle's discovery and exploration of the Mississippi River, says, "The whole country is covered with palms. . . ."[2]

The works of Robin, Darby, and Flint, in the first quarter of the past century, give perhaps the most interesting and fullest discussions of the distribution and growth of these palmettos. In 1807, Robin published an account of his travels in the New World together with a flora of Louisiana. William Darby, a surveyor, after a residence of sixteen years in the State, published in 1816 the first detailed map of Louisiana, accompanied by *A geographical description of Louisiana,* which is replete with careful and accurate observations based upon an intimate knowledge of the region. Flint, who resided for a time in the State, was also an accurate observer, though he acknowledges his indebtedness to Darby and others whose published works preceded his own.

It is interesting to note that the French appellation, *latanier* or *latania,* which is commonly used today in Louisiana to designate the native palmettos, appears in the works of most of the early writers.

[1] Received November 28, 1934.

[2] LE CLERCQ, CHRESTIEN. *Premier établissement de la foy dans la Nouvelle France,* etc. 2: 229. 1691. Paris. This is a very rare work. It contains an account of La Salle's discoveries by two missionaries who accompanied him. The palms were first encountered on the boat trip down the Mississippi in the territory of the Taensa Indians, near the present town of St. Joseph in Tensa Parish.

Latanier is the French form of the native name of a group of tall, fan-leaved palms[3] indigenous to certain islands belonging to France, off the southeast coast of Africa. These palms have long been cultivated in Europe and elsewhere. The French settlers of the New World undoubtedly carried this name over to the fan-leaved palmettos in the new country, Louisiana. Flint even uses[4] the combination *Chemaerops latanier* as a scientific name for the Louisiana palmetto.

Robin gives a description of the palmettos, using vernacular names, but he offers no Latin specific names. He writes,[5]

"Louisiana produces, I believe, only two species of this family [Palmae], common in the woods; the first is the *camérope* or *palmier nain* (*Chamaerops*), commonly called *latanier*, differing from that of southern Europe in that the margins of the leaves are neither toothed nor spiny. The trunk, from which the leaves arise folded in a fan, scarcely emerges from the ground. . . . [There follows a further description of this species.]

"The second species, less common and less beautiful, divides its leaves into two portions, of which each is folded at the ends, somewhat like an old-fashioned cravat or collar."[6]

Although he offers a fairly complete botanical description of his first species, he does not describe the second beyond pointing out a peculiarity of the leaf.

Rafinesque, who translated and revised Robin's *Flora* and assigned binomial names to many of the species mentioned in it, remarks that Robin "does not appear to have been a professed botanist" and, in cataloguing the two palm species, Rafinesque simply places[7] the description of Robin's first species under *Sabal adansoni* (wrongly ascribing the binomial to Persoon instead of to Guersent) and applies a name of his own, "*Sabal ? adiantinum* Raf.," to Robin's second species, evolving a Latin description partly from Robin's remarks and, apparently, partly from conjecture, thus:

"29. *Sabal adansoni*. Pers.—*Palmier nain* ou *Latanier*. Rob. p. 337. Spadix ensiform elastic, rising seven feet, stem-like, branched, flowers trifid

[3] These palms, which have been given the generic name *Latania*, are native to the islands of Bourbon, Mauritius, and possibly, also Madagascar.

[4] "Palmetto, *Chemaerops latanier*. This is a perennial plant, strongly marking climate. It commences in the same regions with long moss,—that is to say, about 33°." Flint, Timothy. *A condensed geography and history of the Western States, or the Mississippi Valley* 1: 85. 1828. Cincinnati.

[5] Robin, C. C. *Voyages dans l'intérieur de la Louisiane . . . Suivis de la Flore Louisianaise* 3: 337–338. 1807. Paris.

[6] This is an interesting observation in view of the fact that, under certain trying growth conditions (open situations exposed to intense insolation and where the ground becomes hard and dry in the summer), the leaves of palmettos in Louisiana are often divided midway into two halves, which curve downward and away from each other.

[7] Rafinesque, C. S. *Florula Ludoviciana*; *or, A flora of the state of Louisiana*. Translated, revised, and improved from the French of C. C. Robin. pp. 16–17. 1817. New York.

white sessile odorate, blossoming in June: berries like a pea, black and sweet. The fibrous netting of the short caudex are used as canvas to clear and scour: the leaves are used to make hats and thatch houses, etc.

"30. *Sabal ? adiantinum.* Raf. Acaule, foliis inermis bipartitis, flabellatis, plicatis. Raf.—2. *Latanier.* Rob. p. 338."

In the same work, Rafinesque includes[8] an *Appendix to the trees and shrubs of Louisiana* in which he lists and comments upon the plants appearing in Darby's work. He seems to have been acquainted only with the second edition, which, although somewhat amplified, includes much the same material as the first edition, but has a different order of treatment.

Darby's accounts of the topography and general vegetation of Louisiana are not only interesting but particularly clear, and, for the most part, amazingly accurate. Of eight specific references to palmettos, the following is[9] of especial interest and is the one to which Rafinesque alludes:

"The *Arundo gigantea* grows in immense brakes in all parts of the parish of Ascension, not liable to annual submersion. Much of that majestic grass has been destroyed by the clearing of the lands; but a vast quantity still remains. Along both banks of New river, in the rear of the plantations on the Mississippi, and on the banks of the Atchafalaya, are the places where most of the *Arundo* yet exists. Here, as well as in every other part of Louisiana, where the land sinks too low for the *Arundo*, is found the *Chamaerops louisiana.** The latter vegetable cannot itself exist, where the inundation exceeds in depth 15 or 20 inches. The land is commonly of the best quality. Much of the surface of the country low upon the Mississippi, now cultivated in cotton, maize, rice, and sugar, was originally covered with the palmetto. From the greater depression of the surface, the palmetto land is more difficult to reclaim, than that naturally covered with *Arundo gigantea*; though equal in fertility when reduced to a state of cultivation.

"The timber trees most usually associated with the palmetto, are, the *Quercus phellos*, *Quercus rubra*, *Acer rubrum*, *Acer negundo*, *Liquidambar styraciflua*, *Ulmus aquatica*, *Cornus alba*, and *Celtis crassifolia*. The *Quercus tinctoria*, and *Quercus virens*, are often found growing upon palmetto land, but not so frequent as the preceding. The *Nyssa aquatica*, and *Cupressus disticha*, would appear from their general history, to be congenial to the palmetto land; the latter tree is sometimes found intermingled, and the

[8] "While the Supplement of this work was under the press, the Geographical Description of Louisiana, by William Darby, fell into my hands. Having perceived in it, several elaborate Catalogues of the trees and shrubs, growing in the different parts of the State, some of which had not been observed by Robin, Bartram, etc. and some additional geographical and economical remarks on others, I have been induced to enumerate those additions, for which we are indebted to Mr. Darby; correcting, at the same time, several errors of nomenclature, into which he appears to have fallen. . . . " Rafinesque. op. cit. 157.

[9] Darby, William. *A geographical description of the state of Louisiana: . . . being an accompaniment to the map of Louisiana.* ed. 1. 193–195. 1816; ed. 2. 81–82. 1817. Philadelphia. The eight references appear on the following pages in the 1816 edition: 68, 77, 88, 193–195, 205, 206, 216, 230.

former growing on inundated land adjacent to; but neither are so commonly met with on palmetto land, as might be expected.

"The palmetto may be correctly considered the vegetable that marks the limit of annual inundation. In all places where we have had good reason to consider the overflow annual, the palmetto ceased. Though able to resist partial and occasional immersion of its roots in water, we are led to believe this shrub would perish if the ground upon which it grew was subject to annual overflow. This does not agree with the writer's observation.

"*[Footnote appears on p. 194 of the original text.] We have given to this vegetable the name of *Chamaerops louisiana* in the text; and are of the opinion that there is a specific difference between the *Chamaerops palmetto* hitherto known to botanists, and that of Louisiana. The *Chamaerops serrulata* of Muhlenberg is certainly not the same with the palmetto of Louisiana; the latter bears a much greater resemblance to the cabbage tree, though much more humble in elevation, than to the saw-leaved palmetto of Georgia."

Rafinesque takes sufficient note of Darby's new specific name to reprint it, but he dismisses[10] both it and Darby's interesting notes in the following manner:

"*Chamaerops Louisiana!* Palmetto or Latania! D. This Palm which Mr. Darby in a note, p. 81, thinks a new species, and to which he gives two erroneous Latin and French names, is merely the *Sabal adansoni* sp. 29. It marks the limit of annual inundation, as it grows above the reach of it."

Rafinesque, in spite of his never having seen Louisiana or its palms, did not hesitate to pass judgment upon Darby's new species. This is especially remarkable in view of Rafinesque's lack of justification for establishing *Sabal ? adiantinum* as a species. There seems to be no valid reason for his considering Darby's binomial name, *Chamaerops louisiana*, erroneous in any respect. This name appears[11] five times in the text of both the 1816 and 1817 editions and in his vocabulary of terms (immediately following the last page of the text) he lists "*Chamaerops louisiana*, . . . Palmetto, or latania." It is worthy of note that Flint later reprints[12] Darby's list of plants, as it appears in the vocabulary of terms, but without citing the source.

In another work of broader scope, Darby gives a general list of trees most likely to be found in Louisiana and adds[13] "On the banks of the streams immense brakes of *Arundo gigantea* (great cane), and on the outer margin of the cane, the palmetto or latania (*Chamaerops Louisiana*), fill the slope between the cane and the dead overflow. . . . The palmetto can support inundation a longer time and deeper than

[10] RAFINESQUE. op. cit. 159–160.
[11] DARBY. op. cit. ed. 1. 194 (twice), 205, 206, 216.
[12] FLINT. op. cit. 2: 486–488. Appendix, Table II.
[13] DARBY, WILLIAM. *The emigrant's guide to the western and southwestern states and territories*, etc. 81. 1818. New York.

the cane. . . ." This reference to the occurrence of palmettos in a zone or belt is an accurate picture of their present distribution in certain situations.

In discussing Prairie Mamou (mostly included in the present Acadia Parish), Darby says,[14] "In the low grounds near the river, the palmetto, called by the French latania, abounds, but not of the gigantic size of its kindred species on the more eastern waters." This statement is doubtless to be interpreted as a comparison with the size of the *Sabal palmetto* of the Carolinas, Georgia, and Florida, which Darby recognizes as a species related to the Louisiana palmetto.

A perusal of Darby's various works should convince anyone who knows Louisiana that he was thoroughly familiar with the material of which he writes. His use of scientific plant names, his references, especially in footnotes, to Miller's *Gardeners Dictionary*, to Michaux, Bartram, Muhlenberg, and other botanists show that he was acquainted with the botanical literature of that time, and it seems unlikely that he would have suggested a name for the Louisiana palmetto without due consideration. His descriptions and names of plants are, however, incidental to his discussions of Louisiana, which probably accounts for his giving only informal notes concerning *Chamaerops louisiana.*

It is unfortunate that Darby gave no formal botanical description of this palm. The following diagnosis, however, may be gleaned from his remarks concerning the Louisiana palmetto: (1) It is fan-leaved—Darby refers to it as the Fan Palmetto[15] or Latania and also compares it with *Chamaerops palmetto* (*Sabal palmetto*) and with *C. serrulata* (*Serenoa repens*); (2) It is unarmed, since Darby expressly states that it is "not the same" as *C. serrulata* [in, not of, Muhlenberg]; (3) It develops a trunk, otherwise there is no reason for saying that it is "not of the gigantic size" of the cabbage-tree, but "much more humble in elevation"; (4) It is indigenous to Louisiana and a very characteristic part of the vegetation; (5) Definite localities are given for its distribution; (6) The list of associated species, including remarks concerning its association with the live oak, *Quercus virens* (*Q. virginiana*), its proximity to tupelo gum, *Nyssa aquatica*, and bald-cypress, *Cupressus disticha* (*Taxodium distichum*), and its occurrence bordering the giant-cane, *Arundo gigantea* (*Arundinaria gigantea*), is adequate to cover situations in which the Louisiana palmetto grows today; (7) The definite claim is made that it is a new species allied to,

[14] DARBY. *A geographical description*, etc., ed. 1. 88.
[15] Ibid., 68.

but different from, the cabbage palmetto, *Sabal palmetto*, that grows farther east. A proper binomial was used by Darby several times and in several publications.

Chamaerops louisiana Darby is the oldest name which the writer has been able to discover which is based upon palmettos growing in Louisiana. The second oldest name, similarly applied, is *Sabal adiantinum* Raf. Rafinesque is responsible for repudiating Darby's name and causing it to have been disregarded by botanists for so many years. The record in the Kew Index, oddly enough, reads "*Chamaerops louisiana* Rafin. Fl. Ludov. 159=*Rhapidophyllum Hystrix?*" The needle palm does not occur in Louisiana.

Rafinesque, by consigning both Robin's first species and Darby's new species to *Sabal adansoni*, is the first botanist to apply that name to palmettos growing in Louisiana. To be sure, Robin's diagnosis coincides fairly well with descriptions of the acaulescent Carolina palmetto but Darby's statement that *Chamaerops louisiana* is not as tall as the cabbage-tree should, of itself, have caused Rafinesque some concern. The next year, 1818, Nuttall applied[16] Guersent's name for the Carolina plant to palmettos in Louisiana, thus: "Species 1. *S. Adansoni*. In troublesome abundance around New Orleans; but less frequent than other species in Georgia and Carolina."

Earlier botanists, including Bartram, Jacquin, Walter, Michaux, Persoon, and Pursh, ascribed the native locality of the Carolina palmetto (also called dwarf palmetto and blue palmetto) to Carolina, Georgia, Florida, or the "sea islands." The nomenclatorial history of this palmetto has been somewhat complicated, the plant having received various names both in this country and in Europe even before 1818. Seeds found their way into the Old World at an early date and it was already in cultivation abroad in the latter part of the eighteenth century. It is not the purpose of this paper to attempt to discuss the applicability of these various names to the dwarf palmetto other than to note that *Sabal adansoni* Guers. (1804) is one of the specific names which was in good standing for many years, although *S. minor* (Jacq.) Pers. is an earlier name.

Martius indicates[17] the range of *S. adansoni* as including New Orleans and the Mississippi Valley as well as Georgia and Carolina. In fact, the extension of the range of the Carolina palm to include

[16] Nuttall, Thomas. *The genera of North American plants*, etc. 230. 1818.

[17] "Crescit gregaria in depressis arenosis udis maritimis Georgiae et Carolinae, frequens in uliginosis in vicinia fluvii Mississippi e. g. propre Aureliam novam, nec non aliis in regionibus sinus floridani." Martius, *Historia naturalis palmarum* 3: 246. 1838.

Louisiana and the identification of the palmettos native to Louisiana with this species and this one alone has been a common practice in floras and manuals and in various works on palms for more than a century. The area covered by Chapman's flora[18] does not embrace Louisiana, the western range limit being Mississippi and Tennessee, but it should be noted that he does not even include Mississippi in the distribution of the dwarf palmetto.

However, in 1926, Dr. J. K. Small described[19] a new species, *Sabal deeringiana*, from Louisiana. This is the "palmetto-with-a-stem," the new species being based upon certain trunked palmettos in the general vicinity of New Orleans. In a later paper, Dr. Small gives[20] a more detailed discussion of these trunked palms, including illustrations of specimens of a very fine stand growing at Frenier Beach, on Lake Pontchartrain, about 40 miles west of New Orleans. Dr. Small points out that Schott must have had trunked palms in mind when he referred[21] to a gorgeous growth in the Mississippi Valley and he quotes Schott in both his papers.

Other botanists have been aware of trunked palmettos in Louisiana and have even mistaken them (as also probably did Schott) for the cabbage-tree, *Sabal palmetto*, the range of which is not believed to extend westward beyond St. Andrew's Bay in western Florida.[22] Featherman writes[23] concerning Grand Isle:[24] "The principal growth is live oak and yaupon in the form of low thickets. A few tree palmettos are seen here and there near the beach. The live oak is low and stunted and grows on a few ridges; . . ." and, in his catalogue of plants in the same publication, we find:

"*Sabal adansonii* Guerns., Dwarf Palmetto, New Orleans, Orleans [Parish];
"*Sabal palmetto*, R. & S. [sic], Tree Palmetto, Grand Isle Jefferson [Parish]."

Palmettos of various ages and sizes, including hundreds of trunked specimens, may be seen today stretching uninterruptedly for almost

[18] CHAPMAN, A. W. *Flora of the Southern United States.* ed. 1. 438. 1860.
[19] SMALL, JOHN K. *A new palm from the Mississippi Delta.* Torreya **26**: 33–35. 1926.
[20] SMALL, JOHN K. *Palmetto-with-a-stem—Sabal deeringiana.* Journ. N. Y. Bot. Gard. **30**: 278–284, *2 figs.* 1929.
[21] SCHOTT, ARTHUR. *Substance of the sketch of the geology of the lower Rio Bravo del Norte*, Part II in Emory, William H. *Report on the United States and Mexican boundary survey* **1**: 44. 1857.
[22] SMALL, JOHN K. *The cabbage tree—Sabal palmetto.* Journ. N. Y. Bot. Gard. **24**: 157. 1923. St. Andrew's Bay is nearly 100 miles east of Pensacola.
[23] FEATHERMAN, A. *Report of botanical survey of southern and central Louisiana made during the year 1870.* 25. 1871. New Orleans.
[24] Grand Isle is a well-known resort on the Gulf of Mexico, about 60 miles south of New Orleans; it is east of the mouth of Bayou Lafourche. Access has been by boat by way of Barataria Bay until 1933, when a road was finally completed to it, connecting with the road which parallels Bayou Lafourche along part of its course.

30 miles from Golden Meadows nearly to Grand Isle. They occupy the slightly elevated ridge land and slope flanking Bayou Lafourche and the road, and may be numbered by the thousands.

Langlois apparently also mistakes[25] the trunked palmettos for the cabbage-tree. Because of his error, some of the earliest records of fungi parasitic on Louisiana palms have been wrongly recorded as occurring on *Sabal palmetto*.[26]

After several years of field observation of palmettos in Louisiana, especially in the vicinity of New Orleans, the writer undertook, in 1933, a detailed survey of the State with the especial aim of discovering, if possible, the distribution and relationship of the trunked and stemless palmettos. The survey was begun in May and continued into November so that flowers and fruits might be studied as well as external vegetative characters. The survey entailed a statistical study of trunked palmettos in more than 40 separate localities in Louisiana and eastward in a few stations along the Gulf Coast as far as western Florida.

Although palmettos are widely distributed over much of eastern and southern Louisiana, they attain their most luxuriant development in the southeastern portion of the State, where the trunked forms occur. Trunked palmettos are much more widespread in Louisiana at the present time than has been supposed, having been found by the writer westward nearly to Opelousas and south almost to the Gulf of Mexico. They are by no means unknown to persons intimately acquainted with the vegetation of the Lower Mississippi Valley, but are ordinarily not seen by the casual observer, since the acaulescent plants are often easily visible from the roadside whereas the trunked palmettos usually occupy the more inaccessible, wetter places beyond. Certain excellent stands of palmettos with nearly erect trunk above ground are readily accessible; e.g., at Frenier Beach, along Bayou Lafourche, and along Paris Road only 4 miles east of the city limits of New Orleans. These, however, are notable exceptions.

Moreover, the palmettos in southeastern Louisiana, at least, give every evidence of constituting a polymorphic species, which shows a remarkable response to a varying combination of habitat factors, of which water and light seem to be of the greatest significance. The writer discovered that the trunked palmettos, wherever they occur, are related to the acaulescent plants by countless transitional forms of

[25] Langlois, A. B. *Catalogue provisoire de plantes phanérogames et cryptogames de a Basse-Louisiane, États-Unis d'Amérique.* p. 17, 1887. Saint-Étienne.

[26] Unpublished data of the writer.

clearly intermediate character. There are situations in which a line transect, run from slightly elevated ridge land to standing water, passes through stemless, intermediate, and trunked palmettos, which show a faithful series of gradations in the size of the leaves, the number of segments, the development of filaments in the sinuses of the blade, the extent of the prolongation of the petiole into the blade, and in the height and branching of the flower stalks.

Variations in the thickness, height, and degree of branching of the flower stalks appear to be most closely correlated with leaf size and general vigor of the plant and secondarily with the presence or absence of a trunk. Variations in the size and texture of the flowers and in the size and proportions of the fruits and seeds are, as far as the writer has been able to determine, slight, and similarly traceable to growth conditions.

The tallest trunk seen by the writer was slightly over 2.5 meters in height; it was one of the palmettos in the senescent stage with reduced leaf crown and telescoped flower stalks. The average actual trunk height of these palmettos in their prime (climax form) is from 1 to 2 meters and the diameter, when devoid of leaf bases, scarcely exceeds 30 cm; with the leaf bases, the diameter may be nearly twice as great. The leaf blades may attain 2 meters in breadth and over 1 meter in length with petioles as much as 1.5 meters long. The erect flower stalks, averaging 5 cm in thickness at the base, become from 3.5 to 4.5 meters tall in the more vigorous specimens, thus making the total height of the climax form, at most, less than 7 meters.

An account of the distribution and growth of the palmettos in Louisiana together with detailed descriptions of the various forms as well as ecological data will be given in another paper.

Until the palmettos of the Southern States have been more fully studied in the field, with especial attention given to their morphological characters at different stages of growth and to the environmental factors, in addition to the study of their flowers and fruits, it cannot be definitely decided what the relationship of the dwarf palmetto is to the Louisiana palmetto, especially in the acaulescent forms. Available data, however, indicate that they are specifically distinct. The dwarf palmetto, *S. minor* (Jacq.) Pers. (*S. adansoni* Guers.), is not known to produce a subarboreal climax form (it has always, in fact, been described as acaulescent or with the caudex slightly elongated); the leaves are sparingly filamentose or without filaments, whereas the Louisiana palmetto has persistent filaments, sometimes occurring in abundance; the petiole is prolonged for only

a few centimeters into the blade, whereas in the Louisiana palmetto the prolongation may extend for as much as 40 cm. Important differences also appear in the number and width of the segments and in the size of the fruits and seeds (the Louisiana palmetto usually has a smaller fruit with a proportionately larger seed). When the erect habit is assumed, the underground portion of the Louisiana palmetto slants from the horizontal and gradually turns upward.

The palm referred to by Darby is unquestionably a species of *Sabal*, and, since *Sabal deeringiana* Small, applied definitely to Louisiana trunked palmettos, is antedated by Darby's name, the plant should be known as *Sabal louisiana* (Darby) Bomhard, comb. nov., the synonomy being as follows:

Chamaerops louisiana Darby, Geog. Descrip. Louisiana ed. 1. 194, also 205, 206, 216. 1816.

Sabal adansoni Raf. Fl. Ludov. 16. 1817, not Guersent, 1804.

Sabal ? adiantinum Raf. Fl. Ludov. 17. 1817.

Chemaerops [sic] *latanier* Flint, Condensed Geog. & Hist. West. States 1: 85. 1828.

Sabal deeringiana Small, Torreya 26: 34. 1926.

ORNITHOLOGY.—*Avian bones from prehistoric ruins on Kodiak Island, Alaska.*[1] HERBERT FRIEDMANN, U. S. National Museum.

During the summer of 1934 Dr. Ales Hrdlicka, curator of physical anthropology, United States National Museum, continued his work on Kodiak Island, and amassed, among other materials, a large collection of bird bone. A smaller lot, collected two years before, yielded so much of value that the study of the present much more extensive material was looked forward to with interest. That it has not been disappointing may be seen from the following account.

The age of the sites from which the bones were exhumed is not known with any accuracy, but they are definitely prehistoric, that is, pre-Russian (late 18th Century). This, of course, involves a span of years too short to be of significance as far as the birds are concerned, however much it may mean anthropologically. The specimens herein reported on were marked in the field according to the relative depth

[1] Published by permission of the Secretary of the Smithsonian Institution. Received November 23, 1934.

at which they were found—deep, intermediate, or superficial. The deeper the deposit, the older are the bones, but here again the time scale for the deposition rate is only inferential. Dr. Hrdlicka estimates the difference in age between the deepest and the superficial layers at about 1500 years.

In order to appreciate the full ornithological significance of the collection, it was first necessary to ascertain just what kinds of birds were known to occur on Kodiak Island. A search of the literature revealed how little work has been done there, especially considering its size and proximity to the mainland of Alaska. No paper dealing exhaustively with the avifauna of Kodiak appears to have been published; this I hope to do in the near future for the benefit of other students of Alaskan ornithology as all the data are now assembled before me.

The present collection contains bones of 40 species of which 7 have not been recorded in literature before from Kodiak Island. These are as follows:

Diomedea nigripes	Black-footed Albatross
Cygnus buccinator	Trumpeter Swan
Chen rossi	Ross's Goose
Nyroca affinis	Lesser Scaup
Glaucionetta clangula	Golden-Eye
Haliaeetus albicilla	Gray Sea Eagle
Stercorarius longicaudus	Long-tailed Jaeger

In Dr. Hrdlicka's 1932 collection, reported on in an earlier paper,[2] were bones of 8 other species that were unrecorded in literature from Kodiak Island. Of these, 5 are also represented in the present collection. These 8 are

Gavia immer	Common Loon
Phalacrocorax carbo sinensis	Chinese Cormorant
Clangula hyemalis	Old Squaw
Arctonetta fischeri	Spectacled Eider
Melanitta deglandi	White-winged Scoter
Melanitta perspicillata	Surf Scoter
Bubo virginianus algistus	Saint Michael Horned Owl
Surnia ulula caparoch	American Hawk Owl

Thus, in two summers' excavating, in a field to one side of the major work of the expeditions, no fewer than 15 species have been added to the recorded avifauna of Kodiak Island. Inasmuch as the total bird population, as far as recorded, comprises about 125 forms, we must credit nearly one-eighth of them to osteological records.

[2] FRIEDMAN, H. This JOURNAL 24: 233–236. 1934.

The following annotated list deals only with the 1934 collection.

GAVIA IMMER (Brünnich). Common Loon.

Two metacarpals were found in the superficial layer. On the basis of geography, these records should refer to the lesser loon, *Gavia immer elasson*, but the races are not to be told with certainty from the bones.

GAVIA ADAMSI (Gray). Yellow-billed Loon.

This large loon was represented in all three depths, the superficial stratum yielding a synsacrum, a tibiotarsus, and a tarsometatarsus; the intermediate depth revealed a metacarpal; a metacarpal and a tarsometatarsus come from the deepest layer.

GAVIA ARCTICA PACIFICA (Lawrence). Pacific Loon.

Represented by a single metacarpal from the deepest layer.

GAVIA STELLATA (Pontoppidan). Red-throated Loon.

A tarsometatarsus from the superficial stratum and a metacarpal from the deepest layer represent this species.

COLYMBUS AURITUS Linnaeus. Horned Grebe.

A tarsometatarsus from the intermediate depth and a humerus from the superficial stratum are the only bones of this grebe found.

DIOMEDEA NIGRIPES Aububon. Black-footed Albatross.

This species, represented by a femur from the deepest layer, 3 femora from the intermediate area, and by 5 femora, 1 synsacrum, and 1 tarsometatarsus from the superficial layer, has not been previously reported from the island.

PHALACROCORAX PELAGICUS Pallas. Pelagic Cormorant.

The bones of this species show great variation in size; if only the two extremes were present, one might think them different species. This cormorant is one of the common birds on Kodiak Island and it is represented by numbers of bones as follows: deepest layer, 5 tarsometatarsi, 4 tibiotarsi, 3 coracoids, 6 femora, 4 humeri, 7 ulnae; intermediate layer, 13 tarsometatarsi, 11 tibiotarsi, 8 coracoids, 21 femora, 18 humeri, 21 ulnae; superficial layer, 2 tarsometatarsi, 10 tibiotarsi, 4 coracoids, 16 femora, 8 humeri, and 11 ulnae.

On the basis of geography these specimens should be of the typical race, *Ph. p. pelagicus*.

CYGNUS COLUMBIANUS (Ord.) Whistling Swan.

The whistling swan is represented by a "thumb" phalanx found in the superficial layer.

CYGNUS BUCCINATOR Richardson. Trumpeter Swan.

The intermediate depth revealed 2 right coracoids and the head of a humerus of this bird. The humerus was notably large, somewhat greater in size than any specimen available for comparison. It had the shaft cut off and had been worked by the early Eskimos as a beveled edge had been made around the cut surface. The superficial layer yielded a fragmentary humerus.

PHILACTE CANAGICA (Sevastinaoff). Emperor Goose.

The emperor goose is represented by a coracoid from the deepest stratum.

ANSER ALBIFRONS (Scopoli). White-fronted Goose.

A metacarpal, found in the intermediate layer, is of this species.

CHEN ROSSI (Cassin). Ross's Goose.

A single ulna from the superficial layer represents this species which is new to the Kodiak fauna. The previous record[3] is erroneous; the bone, a skull, is found, on further study to be that of a black brant, *Branta nigricans*.

ANAS PLATYRHYNCHOS Linnaeus. Mallard.

The mallard is known to breed in the Aleutian Islands and the whole Alaskan peninsula, so its occurrence on Kodiak is wholly to be expected, and the scarcity of previous records must be looked upon as solely due to lack of observation and work in that place. It is represented in the present collection by 54 humeri; of these 3 come from his deepest layer, 16 from the intermediate depth, and 35 from the superficial stratum.

DAFILA ACUTA (Linnaeus). Pintail.

The pintail is represented by 25 humeri, 3 from the deepest, 5 from the intermediate, and 17 from the superficial layers. These bones probably refer to the American subspecies *tzitzihoa*.

NYROCA AFFINIS (Eyton). Lesser Scaup Duck.

Four humeri, 1 from the intermediate, and 3 from the super-

[3] This JOURNAL 24: 234. 1934.

ficial layers, are the only evidence of this duck's occurrence on Kodiak Island.

GLAUCIONETTA CLANGULA (Linnaeus). Golden-eye.

Of this duck the intermediate layer yielded a coracoid; the superficial stratum a syrinx, a skull, and 2 humeri. By virtue of geography the bones should be referred to the American subspecies, *G. c. americana*. The species is new to the Kodiak avifauna, as far as published records go.

CLANGULA HYEMALIS (Linnaeus). Old Squaw.

This duck is represented in all three depths, as follows: deepest layer, 1 humerus, 2 coracoids, intermediate area, 8 humeri, 2 coracoids, superficial layer, 12 humeri, 3 coracoids.

HISTRIONICUS HISTRIONICUS (Linnaeus). Harlequin Duck.

A single coracoid of this duck was found in the superficial layer. It is undoubtedly of the western race *pacificus*.

POLYSTICTA STELLERI (Pallas). Steller's Eider.

Bones of Steller's eider were found in all three depths. The deepest layer revealed 2 humeri; the intermediate layer yielded 9 humeri; the superficial stratum produced 14 humeri, 1 coracoid, and 1 tarsometatarsus.

SOMATERIA V-NIGRA Gray. Pacific Eider.

The Pacific eider is represented by a sternum and a metacarpal from the deepest layer, 3 metacarpals from the intermediate layer, and 2 skulls, 3 tarsometatarsi, and 2 metacarpals from the superficial deposits.

SOMATERIA SPECTABILIS (Linnaeus). King Eider.

This is one of the most abundant waterfowl on Kodiak Island, if we may judge from the number of its bones found. The deepest layer yielded 13 humeri, 1 metacarpal, 4 ulnae, and 3 tarsometatarsi; the intermediate depth produced 17 humeri, 5 metacarpals, 3 ulnae, and 7 tarsometatarsi; from the superficial layer were taken 46 humeri, 2 sterna, 1 skull, 11 ulnae, 2 femora, and 7 tarsometatarsi.

MELANITTA DEGLANDI (Bonaparte). White-winged Scoter.

The collection contains 56 bones of this duck, distributed as follows: deepest layer, 2 coracoids, 3 metacarpals, 6 femurs; intermediate layer, 1 humerus, 1 coracoid, 2 metacarpals, 19 femora; superficial layer, 1 skull, 3 metacarpals, 18 femora.

MELANITTA PERSPICILLATA (Linnaeus). Surf Scoter.

The surf scoter is represented by a femur from the deepest layer, 7 femora and a tibiotarsus from the intermediate stratum, and 6 femura, 3 tibiotarsi, 2 skulls, and 2 sterna from the superficial deposits.

OIDEMIA AMERICANA Swainson. American Scoter.

A coracoid and 2 humeri from the intermediate layer, and a coracoid and 6 humeri from the superficial stratum are of this species.

HALIAEETUS ALBICILLA (Linnaeus). Gray Sea Eagle.

This eagle is represented by 2 tarsometatarsi and 1 metacarpal from the surface deposits. It is not only a new bird for Kodiak Island, but is the fourth known record for North America, the others being from Unalaska, Cumberland Sound, and off the coast of Massachusetts.

HALIAEETUS LEUCOCEPHALUS (Linnaeus). Bald Eagle.

The bald eagle is abundant on Kodiak Island and is well represented in the present collection. From the deepest layer come 2 humeri, 2 coracoids, 1 clavicle, 1 scapula, 2 tarsometatarsi and 3 metacarpals; from the intermediate stratum are 1 synsacrum, 2 humeri, 3 femora, 4 coracoids, 4 tibiotarsi, 1 scapula, 4 tarsometatarsi, and 11 metacarpals; from the superficial layer are 2 sterna, 4 fragments of synsacra, 12 skulls or fragments of skulls, 10 humeri, 15 femora, 6 coracoids, 10 tibiotarsi, 2 ulnae, 1 scapula, 10 tarsometatarsi, and 12 metacarpals.

THALASSOAETUS PELAGICUS (Pallas). Steller's Sea Eagle.

This fine eagle was previously known from Kodiak Island on the basis of one record, a bird shot there on August 10, 1921 by C. H. Gilbert.[4] It is of interest to find that bones referable to it are included in the present collection, as follows: from the deepest layer 2 humeri, from the intermediate layer, 1 synsacrum (fragment), 2 humeri, 1 metacarpal, 2 tarsometatarsi, 1 caracoid, 2 tibiotarsi, and 1 claw; from the superficial layer, 1 sternum, 1 synsacrum (fragment), 1 pair of mandibles, 2 metacarpals, 2 ulnae, 1 tarsometatarsus, 4 femora, and 3 tibiotarsi.

GRUS CANADENSIS (Linnaeus). Little Brown Crane.

This bird has been recorded but once previously from Kodiak Island. It is represented in the present collection by a radius from the

[4] Condor 24: 66. 1922.

intermediate area, a coracoid, a tarsometatarsus, and an ulna from the surface deposits.

STERCORARIUS LONGICAUDUS Vieillot. Long-tailed Jaeger.

Three humeri from the intermediate and superficial layers represent this species. It is new to Kodiak Island.

LARUS GLAUCESCENS Naumann. Glaucous-winged Gull.

A good number of bones of this gull were found, as follows: in the deepest layer, 1 humerus, 2 ulnae, 3 femora, 2 tarsometatarsi and 4 metacarpals; from the intermediate layer, 6 humeri, 2 tibiotarsi, 1 coracoid, 2 femora, and 9 metacarpals; from the superficial layer, 4 humeri, 1 coracoid, 1 femur, 2 tarsometatarsi, and 11 metacarpals.

LARUS ARGENTATUS Brunnich. Herring Gull.

From the deepest layer 1 metacarpal was collected; from the intermediate depth came 4 humeri, 1 coracoid, 1 tarsometatarsus, and 9 metacarpals; from the superficial layers 2 humeri, 1 coracoid, 2 tarsometatarsi, and 2 metacarpals were collected. The bones may refer to the race *smithsonianus*, or to *thayeri*, or even to *vegae*!

LARUS CANUS BRACHYRHYNCHUS Richardson. Short-billed Gull.

This gull is represented by 3 tarsometatarsi from the superficial layer.

URIA AALGE CALIFORNICA (Bryant). California Murre.

URIA LOMVIA ARRA (Pallas). Pallas's Murre.

Bones of these two murres are practically indistinguishable and accordingly I have had to treat them together. Both species are very common on Kodiak Island and both are undoubtedly present in the following series of bones. From the deepest layer, 57 humeri, 1 skull, 1 tarsometatarsus, 1 tibiotarsus, 26 ulnae, 2 metacarpals, 10 femora; intermediate layer, 53 humeri, 3 skulls, 1 synsacrum, 1 tarsometatarsus, 2 tibiotarsi, 18 ulnae, 3 metacarpals, 6 femora; from the superficial layer, 43 humeri, 1 sternum, 7 skulls, 1 clavicle, 15 ulnae, 5 coracoids, 6 metacarpals, 12 femora.

CEPPHUS COLUMBA Pallas. Pigeon Guillemot.

This bird is represented by 2 ulnae from the deepest deposits and 2 ulnae and 2 humeri from the surface layers.

CYCLORRHYNCHUS PSITTACULA (Pallas). Paroquet Auklet.

Of this auklet there are 14 humeri, 7 from the deepest, 3 from the intermediate, and 4 from the superficial layers.

LUNDA CIRRHATA (Pallas). Tufted Puffin.

The tufted puffin is represented by bones from all three depths, as follows: deepest layer, 3 humeri and 3 ulnae; intermediate layer, 2 humeri, 1 femur, 1 metacarpal, and 6 ulnae; superficial layer, 1 sternum, 1 humerus, 1 femur, 2 ulnae, and 1 tibiotarsus.

PICA PICA HUDSONIA (Sabine). American Magpie.

One femur from the deepest layer; 1 humerus from the intermediate stratum; and 2 skulls, 1 tarsometatarsus, and 1 femur from the superficial layer refer to this species.

CORVUS CORAX PRINCIPALIS Ridgway. Northern Raven.

The raven is common on Kodiak Island and is well represented in the present collection as the following list shows. From the deepest layer, 1 skull, 1 humerus, 3 ulnae, 1 tibiotarsus, 3 metacarpals, 1 coracoid, and 4 tarsometatarsi; from the intermediate layer, 6 humeri, 6 ulnae, 1 radius, 6 tibiotarsi, 5 metacarpals, and 1 tarsometatarsus; from the superficial layer, 3 skulls, 8 humeri, 7 ulnae, 5 tibiotarsi, 11 metacarpals, and 4 femora.

CORVUS BRACHYRHYNCHOS CAURINUS Baird. Northwestern Crow.

The small, northwestern crow is a common inhabitant of Kodiak Island. Its bones were found in all the layers of the excavations, as follows: from the deepest stratum, 2 femora, 1 tibiotarsus, and 3 ulnae; from the intermediate depth, 6 femora, 4 tibiotarsi, and 2 ulnae; from the superficial layers, 1 skull, 5 humeri, 3 femora, 5 tibiotarsi, and 17 ulnae.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

Science Advisory Board.—Through the Science Advisory Board, created by presidential executive order last year, scientists not on the Government payroll have been active in the reorganization of the work of not less than six bureaus in various departments of the Federal Government, under the program authorized by act of Congress early in 1933. They have also advised on the scientific problems confronting a number of independent Government agencies not connected with any special department.

Major revisions and extensions of program were contemplated by the Government in the Weather Bureau and the Bureau of Chemistry and Soils of the Department of Agriculture, in the National Bureau of Standards of the Department of Commerce, and in the Bureau of Mines, the Geologi-

cal Survey, and the Soil Erosion Service of the Department of the Interior. In all these studies the Science Advisory Board participated by invitation of the Government; and it was also invited to take part in such diverse non-departmental matters as the modernization of railroads, the study of peoples' fitness for new jobs, and the unearthing of valuable archaeological data from mounds and other Indian sites in the Tennessee valley before they were drowned forever under the backwaters of the new dams.

Many of the tasks of the Board are already finished. The first one, which was indirectly responsible for the creation of the Board, was the reorganization of the U. S. Weather Bureau. This has been completed, and we are on the way toward a better knowledge of the weather and its practical forecasting. The saving of the old Indian records, which necessarily had to be done rapidly, is also a closed job.

Some of the Board's tasks are still in progress. Notable among these is the work of the committee on land use, and also the development of better coordination between the numerous separate mapping agencies of the government.

Some of the Board's activities are of necessity continuing projects, since they concern problems that either have no end, or at least will require decades of work to close them up. Such are the decentralization of industry and the application of scientific knowledge to the technical and medical problems of the Army and Navy.

The first report of the Science Advisory Board tells of progress during its first year of existence. Government officials are in general agreement with prominent scientists, that the Board has proved an effective mechanism for making available to the country its own resources in scientific knowledge.

More Research Called For.—Vigorous support for a program of fundamental scientific research featured Secretary WALLACE's annual report to President ROOSEVELT. In normal times it enables farmers, stockmen and foresters to get the best returns from the land with the least outlay in money and labor. And in the present period of emergency a number of hitherto undermanned research projects have been enabled to go ahead by turning the efforts of unemployed men and women against some of the very ills that made them jobless.

"Research is the Department's biggest job; indeed, research is the foundation of everything it does," Secretary WALLACE declares. "It could not help farmers to plan their production, to reduce their costs, to fight the diseases and pests that attack animals and plants, to produce better crops and livestock, and to market their products efficiently, without first studying how these things may be done."

The frequently-offered criticism, that research increases crops just when the Department is trying to reduce surpluses, the Secretary combats as a fallacy. By discarding the benefits of science, crops could be reduced, he admits, but it would be at the cost of wasted labor and exhausted land resources. The right method of control, he insists, is first to reduce unit costs of production, and then adjust the number of units produced to the capacity of the market to absorb them.

Smithsonian Institution.—A camp site abounding in Folsom-type culture remains was discovered in an arroyo in Colorado by Dr. FRANK H. H. ROBERTS, JR., of the Bureau of American Ethnology. The finds consisted not only of Folsom points but of the cores from which they were struck, as well as bones split for marrow and charcoal hearths, indicating permanent

occupation. This represents the first known Folsom *settlement.* The site has not yet been explored, but only prospected.

An expedition into the jungles of Panama, led by DR. WILLIAM D. STRONG, has produced culture remains believed to be of great importance in tracing the history of the development and migrations of indigenous American cultures. The finds, consisting of star-headed stone warclubs, pottery, and human figurines, all show South American affinities.

A fossil vertebra of a veritable sea serpent, picked up at Belvedere Beach, Va., by Dr. W. GARDNER LYNN of the Johns Hopkins University, has been turned over to the U. S. National Museum. It represents a new species of *Paleophis,* a swimming python-like snake perhaps 25 feet long. It has been described under the name of *P. virginianus* by C. W. GILMORE.

The present revival of gold mining in Mexico has been of indirect benefit to the U. S. National Museum; a large quantity of specimens of rare minerals, including livingstonite and vesuvianite, has been obtained from mines in the southern part of that country by Dr. W. F. FOSHAG, curator of minerals.

Pan-American Union.—Surgeon General H. S. CUMMING and Dr. B. J. LLOYD, Director and Assistant Director, respectively, of the Pan American Sanitary Bureau, were two of three delegates of the United States at the Ninth Pan American Sanitary Conference, held in Buenos Aires, November 12–22, 1934. Dr. JOHN D. LONG, Traveling Representative of the Bureau, also attended.

Dr. A. A. MOLL, scientific Editor of the Pan American Sanitary Bureau, gave a lecture before the Johns Hopkins Medical History Club on *Physicians in public life, especially in Latin America.*

Surg. Gen. H. S. CUMMING has been re-elected Director of the Pan American Sanitary Bureau of the Ninth Pan American Conference.

The Cuban Government has just granted the Finlay decoration to Dr. L. O. HOWARD, former Chief of the U. S. Bureau of Entomology; Brig. Gen. J. R. KEAN, and Dr. A. A. MOLL. The latter is the author of a biographical essay on Finlay.

New officers of the Washington, D. C. Chapter of the Pan American Medical Association are Dr. HENRI DE BAYLE, Charge d'Affaires of Nicaragua, President, Surg. Gen. ROBERT U. PATTERSON, Vice President, and Dr. A. A. MOLL, Secretary.

National Bureau of Standards.—The many friends of Dr. PAUL R. HEYL will be glad to learn that he has returned to his work at the Bureau after a remarkably rapid recovery from his serious accident last October.

Dr. H. C. DICKINSON addressed the student section of the American Society of Mechanical Engineers at George Washington University on the evening of December 5. His subject was *An invitation to clear thinking about the organism which controls the distribution of work and wealth in civilized society.*

Dr. H. C. DICKINSON presided at the traffic session of the engineering and industrial research division, Highway Research Board on December 6. This session formed part of the fourteenth annual meeting of the Board which was held at the National Academy of Sciences, Washington.

Terrestrial Magnetism Observations.—The United States Coast and Geodetic Survey and the Department of Terrestrial Magnetism of the Carnegie Institution of Washington are making a joint attack on the problems of more rapid and convenient absolute magnetic observations and of more con-

sistent performances of variometers for vertical intensity at observatories. The program includes exhaustive tests of existing instruments and development of new ones particularly electrical methods of recording, with the special aim of a combination of accuracy, rapidity, and convenience which has not as yet been attained by other methods.

STUART L. SEATON, of the Department of Terrestrial Magnetism, sailed from New York November 15, 1934, for Watheroo, Western Australia, where he will join the staff of the Magnetic Observatory operated by the Department at that place. He will pay especial attention to ionospheric research. En route he will call on various officials in Australia who are interested in the work in which he will be engaged.

Cause of Stratosphere Balloon Failure.—Because the giant stratosphere balloon, Explorer, on its ill-fated flight in July had the lower part of its rubber-sticky fabric tucked up inside the balloon, great tears occurred which brought a precipitate ending to the flight. This was the finding of a scientific inquiry as to the cause of the accident made by a board of review consisting of Dr. L. J. BRIGGS, Chairman, National Bureau of Standards, Dr. JOHN O. LA GORCE, National Geographic Society, Brig. Gen. O. WESTOVER, U. S. Army Air Service, Dr. W. F. G. SWANN, Bartol Research Foundation, and Dr. L. B. TUCKERMAN, National Bureau of Standards, as reported by Dr. BRIGGS and Dr. TUCKERMAN.

To avoid difficulty in inflation and launching, great folds of fabric that would not be expanded by gas until the balloon had risen about 60,000 feet in its 75,000 foot projected climb were accordion folded inside with the idea that as the bag increased in size in the rarefied atmosphere it would come loose neatly. But the designers did not realize that the new way of folding would not allow the adherent rubber-coated fabric to peel loose, as happens with the usual method of folding. The inside layers became taut first, setting up shearing stresses that broke the fabric. So at 60,000 feet, the tears began and forced a descent. An explosion of the lifting hydrogen gas mixed with air oxygen admitted by the torn balloon was the final act in the disaster and caused the disintegration of the balloon.

The Fight for the Elms.—With the $527,000 of PWA funds, Department of Agriculture forces fighting the elm disease have moved into the area around New York City, to start a campaign of extermination against all trees found to be harboring the disease or the beetles that carry its causal fungus. In the wooded country, men of the CCC will cut down and destroy the sick and dead elms. In the cities, workmen under the direction of experts will take out the doomed trees, sawing them limb by limb as they stand rather than felling them, to avoid damage to telephone and electric wires as well as to buildings. This greatly increases the cost of removal, but the expense cannot be avoided.

An area with a radius of some 45 miles around New York City is known to harbor the diseased trees. Elimination must be made complete in this region, or the disease will start over again. In addition, a ten-mile "safety zone" outside the known infested area is also marked for cleaning up. In all, 5,000 square miles, containing 3,000,000 trees, must be policed.

Self-Reporting Earthquakes.—Earth's rigid rocks, and its iron core, proved faster messengers of the Chilean and Honduran earthquakes than did the wires man strings along the surface. The Honduran earthquake occurred on the night of Sunday, December 2. Early on Monday morning telegrams began to arrive in Washington, informing the U. S. Coast and

Geodetic Survey and Science Service of the records traced on seismographs of observatories all the way from Tucson, Ariz., to San Juan, P. R., and making possible the location of an epicenter in Honduras. Only on Tuesday, December 4, did meager reports trickle through a patched-up communication system to tell the world of wreckage in the interior of the Central American country.

Similarly, instrumental reports of the Chilean earthquake were in the hands of seismologists some hours before telegraphic reports of damage in the northern mountain provinces came through.

The instrumental reporting of earthquakes is maintained through a cooperative arrangement of the U. S. Coast and Geodetic Survey, Science Service, the Jesuit Seismological Association and numerous universities in the United States and abroad.

NEWS BRIEFS

Approximately 1800 lots of seed, mostly of grasses and other plants of sand and soil-binding value, have been brought back from Russian Turkestan and Asiatic Turkey by H. L. WESTOVER and C. R. ENLOW of the U. S. Department of Agriculture. They represent the fruits of a seven months' expedition.

The Bureau of Entomology, U. S. Department of Agridulture, expects a severe outbreak of chinch bugs in the central grain areas in 1935, but anticipates less trouble from grasshoppers than there has been during the past few years.

PERSONAL ITEMS

A bronze plaque, the annual award for meritorious service in the fields of medicine and science given by the New Jersey Health and Sanitary Association, was presented in absentia on November 16 to Dr. THEOBALD SMITH, formerly of the U. S. Department of Agriculture.

One of the outstanding honors that can be won by students of the life sciences, the Joseph Leidy medal, has been given to GERRIT SMITH MILLER, JR., of the U. S. National Museum, by the Academy of Natural Sciences of Philadelphia. The Leidy medal is awarded for distinguished work in the natural sciences. In announcing the selection of Mr. MILLER as its fourth recipient, the committee cited "his extensive and fundamental studies on the structure, classification, distribution and evolution of the mammals."

Dr. H. E. EWING, entomologist in the Bureau of Entomology and Plant Quarantine, has accepted an invitation to deliver ten lectures to the class in medical entomology at the Johns Hopkins University School of Hygiene and Public Health.

DR. CHARLES ARMSTRONG, attached to the National Institute of Health, U. S. Public Health Service, has recovered from a three weeks' attack of an unknown illness, which may have been an attack of encephalitis. He has been conducting research on that disease continuously since the epidemic in St. Louis in 1933.

Prof. H. M. JOHNSON of American University lectured at Yale University on Friday evening, November 23, and at the University of Virginia on Friday evening, December 8.

Dr. S. F. HILDEBRAND, senior ichthyologist of the U. S. Bureau of Fisheries, has been elected to honorary membership in the Panama Canal Natural History Society in recognition of his contributions to the knowledge of neo-tropical ichthyology.

Assistant Director CONRAD L. WIRTH, in charge of the branch of planning and the State Park Division, U. S. National Park Service, has been named chairman of the Committee on National, State and Provincial Parks of the American Institute of Park Executives.

Journal of the Washington Academy of Sciences

This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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PHARMACOLOGY.—*The relationship between time of administration and effectiveness of remedies for cyanide poisoning.*[1] JAMES F. COUCH, H. BUNYEA, and A. B. CLAWSON, Bureau of Animal Industry.

In the studies previously reported[2] it appeared that promptness in administration of the remedy in cyanide poisoning was an important factor in protecting the animal against a fatal outcome. Data as to just how soon the remedy must be given were lacking, however, and it was with the idea of supplying some definite information on this point that the experiments reported in this paper were conducted. We had previously shown that the combination of sodium nitrite and sodium thiosulphate is the most effective remedy for cyanide poisoning in both cattle and sheep, and that it is possible to protect against

TABLE 1.—EFFECT OF VARYING INTERVAL BETWEEN DRENCHING WITH 1.5 M.L.D. OF CYANIDE AND GIVING THE REMEDY

Date 1934	Sheep No.	Weight kg	Time from end of drench			Remedy	Effect
			to first symptoms	to collapse	to giving remedy		
Aug.			min.	min.	min.		
29	1493	43.6	1	1.5	11.5	1g nitrite & 2g thiosulphate	Died
29	1537	45.9	1.5	1.75	7.5	do	Died
29	1487	39	0.5	2	12	do	Survived
29	1485	39	1	2.5	12.5	do	Died
29	1480	34.45	1	2	3	do	Survived
29	105A	39.5	1	1.5	9.5	do	Died
29	1509	43.1	1.5	1.75	8.75	do	Died
29	1488	45.45	1.5	3	8	do	Died
30	1467	40.8	1	1.5	32.5	do	Survived
30	1479	41.2	2	4	18.5	do	Survived
30	1482	31.7	1.5	2.5	4	do	Survived
30	1526	37.5	1.5	3	5	do	Died
30	100A	35.8	1.5	2	6	do	Died
30	101A	34.9	1	2	7	do	Died
30	1519	35.8	1	3	5	do	Died
30	1484	36.2	1	2	5	0.5 g methylene blue	Died
30	103A	34.9	1.5	2	7	do	Died
30	1500	39.9	1	2	7	do	Died
30	1466	48.07	1	2	4	do	Died

[1] Received January 3, 1935.
[2] This JOURNAL 24: 369–385, 528–532. 1934.

2 m.l.d. of potassium cyanide in cattle and 2.75 m.l.d. in sheep. It remained to determine how soon after the cyanide was given the remedy must be injected in order that the animal might survive. This paper records only the results obtained with sheep.

The results are summarized in table 1. Nineteen experiments were performed with sheep of which 15 were given 1g of sodium nitrite and 2g of sodium thiosulphate in water solution, and four were given 50 c.c. each of 1 per cent methylene blue solution for comparison. As previously described the potassium cyanide was given by mouth. The dose of cyanide given was calculated to equal 1.5 m.l.d. or just high enough to ensure death in all cases and yet much smaller than the upper limit of possible protection (2.75 m.l.d.). The remedy was administered intraperitoneally at varying times following the completion of the drenching. The animals exhibited the first symptoms, accelerated respiration, in from $\frac{1}{2}$ to 2 minutes after the drench, averaging 72 seconds, and collapsed in 1.5 to 4 minutes after the drench averaging 132 seconds. Dyspnea was present in all cases at the time the remedies were injected and was very marked in the delayed cases.

Three cases were encountered in which the course of the poisoning was atypical. Sheep No. 1487 after showing symptoms in $\frac{1}{2}$ minute and collapsing in 2 minutes after the drench, showed improvement, recovered consciousness, rolled upon the sternum and remained there. Six minutes later the sheep began to show dyspnea and one minute after was breathing with considerable difficulty. She was then given the combination remedy 12 minutes after the drench. Forty-eight minutes after the injection of the remedy she rose to her feet and shortly appeared fully recovered.

Sheep No. 1467 behaved similarly. After collapsing the sheep remained down for 1.5 minutes and then got to her feet and remained standing for 20 minutes before lying down. The animal developed symptoms of dyspnea and 32.5 minutes after the drench was very sick. She was then given the remedy and improved, got on her feet in 51 minutes and recovered. Sheep No. 1479 likewise got to her feet after collapsing and remained standing for 6 minutes when she went down and became dyspneic. In 18.5 minutes after the drench the sheep was very sick. She was given the remedy, got back on her feet in 21 minutes and recovered.

In the other cases more regularity was observed. There was a progressive development of symptoms without periods of improvement before the remedy was injected. When 3 and 4 minutes only had elapsed

between the completion of the drench and the administration of the nitrite-thiosulphate combination the sheep recovered. A longer interval was followed by death. As methylene blue has been recommended as a remedy, for purposes of comparison 4 sheep were treated with 50 c.c. of 1 per cent solution intraperitoneally at 4, 5, 7, and 7 minutes after the completion of the drench and all died.

SUMMARY

The combination of 1 gram sodium nitrite and 2 grams of sodium thiosulphate used as a remedy in cyanide poisoning is effective when administered promptly. The combination protected when injected intraperitoneally within 4 minutes after drenching an average sized sheep with 1.5 m.l.d. of potassium cyanide, but did not protect after a longer interval except in the cases of unusually resistant sheep. One half of a gram of methylene blue in solution similarly administered did not protect in 4 minutes. Three sheep out of 19 showed atypical behavior when poisoned with the cyanide.

ZOOLOGY.—*A new species of* Oochoristica *from a skunk.*[1] MARY SCOTT SKINKER, Bureau of Animal Industry. (Communicated by E. W. PRICE.)

Members of the genus *Oochoristica* are found in a wide range of vertebrate hosts, but they occur most frequently in reptiles. Meggitt (1934) gave a comparative table of most of the species of the genus; he did not include 5 species described by Harwood (1932) or *O. parva* (Sandground, 1926) Meggitt, 1934. He explained that the omission of *O. parva* was due to the fact that no description was available, and it is probable that none was available for the species described by Harwood. The description of *O. thapari* Johri, 1934 from *Calotes* sp. has been published since Meggitt's paper appeared. Of the species included in Meggitt's table, 5 (including *O. parva*) are from carnivore hosts. These 5 species and the one described in this paper represent the known species from carnivores; a comparative table of these is included.

Family ANOPLOCEPHALIDAE Cholodkowski, 1902
Subfamily LINSTOWINAE Fuhrmann, 1907
Genus OOCHORISTICA Luehe, 1898

Generic diagnosis.—Genital pores usually unilateral, only infrequently irregularly alternating. Genital ducts passing between or dorsal to longitudinal excretory vessels. Longitudinal excretory vessels variable in number,

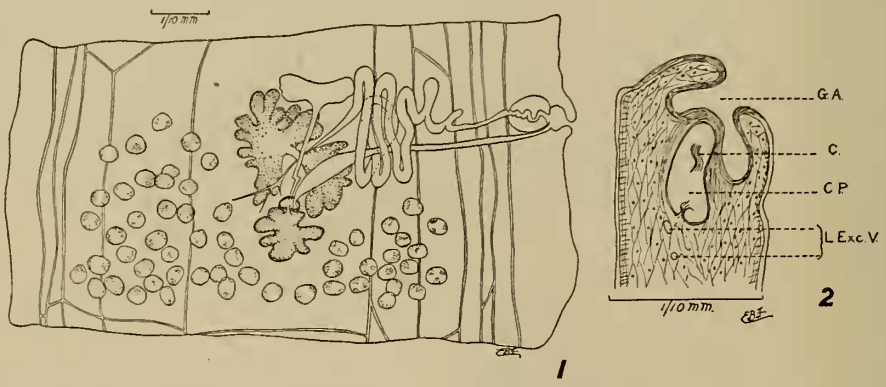
[1] Received November 6, 1934.

frequently with secondary ramifications. Testes numerous, i.e., usually more than 10. Female reproductive organs median; uterus a transverse tube breaking up into egg capsules, each containing a single egg. Adults in primates, carnivores, insectivores, edentates, marsupials, and reptiles; larval stages unknown.

Oochoristica mephitis, n. sp.

Scolex.—Maximum diameter 429 to 689μ; suckers usually somewhat longer than wide; only rarely circular in outline, 159 to 220μ long by 130 to 183μ wide.

General anatomy of strobila.—Length of gravid strobila 11 to 25 mm.; width usually variable, up to 1.3 mm. Neck (unsegmented region) present or absent according to state of contraction, if present usually only slightly



Figs. 1–2.—*Oochoristica mephitis.* Fig. 1.—mature segment. Fig. 2.—Region of genital atrium. Drawn from cross section. C., cirrus; C. P., cirrus pouch; G. A., genital atrium; L. Exc. V., longitudinal excretory vessel.

narrower than greatest diameter of scolex. Segments about 40 to 70 in number in strobilae with fully developed oncospheres; immature segments 20 to 40 in number, the posterior 5 to 10 segments showing only testes (i.e., ovary not yet developed); fully mature segments 2 to 10 in number, usually about 3, these usually widest of strobila; gravid segments 7 to 23 in number, usually narrower than mature segments and usually longer than wide, sometimes approximately square; in a specimen 11 mm. long, gravid segments 715μ square. Genital papillae about one-third segment length from anterior margin in mature segments, usually in middle of segment margin in gravid segments. Genital atrium (Fig. 2) conspicuous, variable in shape, usually about 35 to 40μ in greater diameter. Longitudinal excretory canals inconspicuous and difficult to demonstrate in whole mounts, variable in number and arrangement, usually 4 to 6 (Fig. 1) on each side, most laterally situated canals usually about 110μ from segment margin; transverse canals irregular in arrangement (Fig. 1) but tending to form a somewhat definite posterior canal in each segment. Longitudinal muscular layer poorly developed; transverse muscles scattered, few in number. Calcareous corpuscles few in the material available.

Male reproductive system.—Testes 44 to 77 in number, sometimes slightly oblong, size varying with stage of development, actively functioning testes up to about 40μ in greater diameter, distributed posterior and lateral to

ovary with tendency toward distribution in two groups in mature segments, poral group smaller, testes not extending laterad beyond most lateral excretory canal. Cirrus pouch usually extending nearly to most lateral longitudinal excretory canal, usually approximately spherical, 55 to 65μ in diameter, sometimes slightly greater in the diameter which lies along transverse axis of strobila. Vas deferens without coils in early development, in wide coils in mature segments, sometimes disappearing abruptly in early gravid segments, usually still visible in terminal segments, passing along the middle of ventral surface of ovary.

Female reproductive system.—Ovary at first distinctly bilobed, later variable in shape, but with tendency toward crescentic outline. Oviduct (Fig. 3) passing from middle of posterior margin of ovary to vagina, surrounded

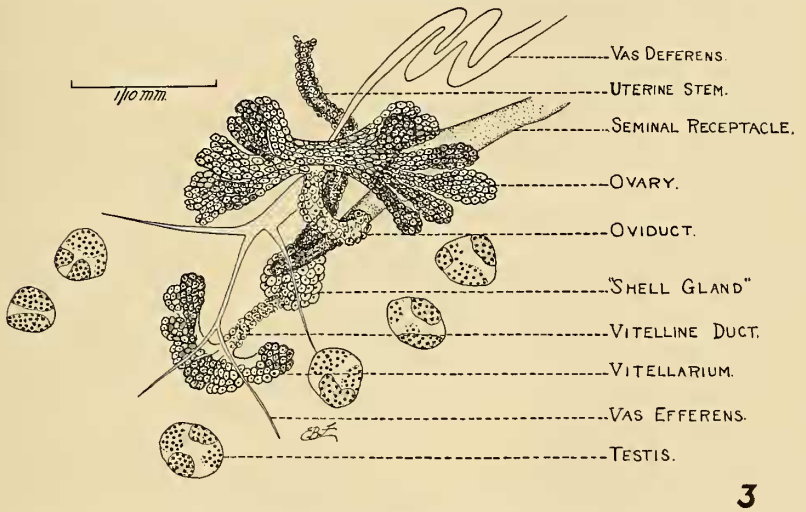


Fig. 3.—*Oochoristica mephitis*. Details of median reproductive organs. Ovary not fully developed.

by large nucleated cells. Vitellarium at first crescentic in outline, later usually irregular in outline, composed of numerous lobules made up of cells slightly smaller than those of ovary; vitelline duct surrounded by large nucleated cells. "Shell gland" (Fig. 3) approximately globular in shape, composed of (or surrounded by?) large cells. In a gravid specimen 11 mm. long with about 40 segments, other measurements as follows: Typical mature segment 1.23 mm. wide by 0.65 mm. long; ovary about 192μ long and 192μ wide; shell gland about 40μ in diameter; vitellarium about 92μ in diameter. Ovary not developing until after testes are well developed; ovary then developing rapidly and disappearing abruptly at appearance of first eggs in uterus. Uterine stem passing from "shell gland" along longitudinal axis of segment to a point approximately parallel to anterior edge of ovary, surrounded by relatively large nucleated cells; with further development, uterine stem (Fig. 3) bifurcating anteriorly and forming a transverse tube, the tube eventually breaking down and egg capsules filling entire segment. Vagina without coils, opening posterior to opening of cirrus sac. Seminal receptacle conspicuous, about 145μ to 185μ long by 43μ to 50μ in maximum width, dorsal to poral lobe of ovary, frequently visible along with vas def-

TABLE 1.—The Species of Oochoristica Found in Carnivores

Species	Length (in mm.)	Width (in mm.)	Diameter of scolex (in μ)	Diameter of suckers (in μ)	Length of cirrus pouch (in μ)	Extent of cirrus pouch	Testes, number and arrangement	Seminal receptacle	Diameter of egg (in μ)	Relation of genital ducts to excretory vessels	Hosts and locality
amphisbeteta Meggitt, 1924	15–40	0.45–0.50	210	165	111	Beyond lateral excretory vessel	22–24; posterior to ovary	Absent	30	Between; dorsal to nerve	*Herpestes auropunctatus* (Hodgson, 1836); India.
herpestis Kofend, 1917	60	3	290	—	220	To ventral excretory vessel	50–60; posterior and lateral to ovary; in 2 layers dorsoventrally	—	57×32	Dorsal	*Herpestes sanguineus* Rüpp.; Africa (Soudan). *Atelerix spiculus* (Thomas and Wroughton, 1907), *A. spinifex* Thomas, 1918; Africa (Nigeria).
ichneumontis Baer, 1924	100	4	—	—	200	To nerve	99–100; posterior and lateral to ovary, extending beyond excretory vessels; in single layer	Absent	46 (oncosphere 30)	Dorsal	*Herpestes gracilis* (Rüpp.) *Galerella gracilis* (Ruppell, 1835); Union of South Africa. "*Foetorius* sp." [? Ictonyx sp.]; Africa (Rhodesia).
ineisa Railliet, 1899	10–150	1.3	270–600	80–120	100–130	(No drawing available)	23–50; posterior and lateral to ovary	Small	30 (oncosphere 23μ)	Between	*Meles meles* (Syn. *M. taxus* Schreb.); Europe (France). *Crocidura caerulea* (Kerr, 1792); Asia.
mephitis n. sp.	11–25	1.3	429–689	159–220 by 130–183	55–65	To lateral excretory vessel	44–75; posterior and lateral to ovary, in one irregular layer.	Present	30	Dorsal	*Mephitis elongata;* United States (Georgia).
parva (Sandground, 1926) Meggitt, 1934	1.3–10.6	650–750	750	140	90	Beyond lateral excretory vessel	40–60; posterior and lateral to ovary; several between vagina and vas deferens	Present	24×21	Dorsal; ventral to nerve	*Nasua socialis;* Brazil.

erens in terminal gravid segments. Eggs, when containing fully developed oncospheres, about 30μ in diameter.

Hosts.—Definitive: *Mephitis elongata;* intermediate: Unknown.

Location.—Small intestine of definitive host.

Distribution.—United States (Georgia).

Type specimen.—United States National Museum No. 32859, collected by Dr. Eloise Cram of the Zoological Division.

Specific differentiation.—The present writer considers the number and arrangement of testes, the size of the cirrus pouch and its position with reference to the other genital organs and especially to the excretory canals and nerve, the presence or absence of a seminal receptacle, the type of genital atrium, i.e., whether massive or with relatively little musculature, the relative position of the genital ducts and excretory canals, and the size of the egg the best characters for specific differentiation. *Oochoristica mephitis* may be separated from the other members of the genus by comparison of the species with regard to these characters as shown in Meggitt's table. In some cases such as *O. cryptobothria* (Linstow, 1906) La Rue, 1911 the description is so inadequate as to prevent comparison, but where relatively complete descriptions are given, one or more of the characters listed above will serve to separate all species from *O. mephitis.* The accompanying table gives only the species found in carnivores, and in it *O. mephitis* may be distinguished from *O. amphisbeteta* and from *O. ichneumontis* on the basis of the presence of a seminal receptacle in *O. mephitis;* in *O. amphisbeteta* the testes are distributed lateral to the most lateral excretory canal, whereas in *O. mephitis* no testes lie outside the most lateral excretory canal. *O. herpestis* is a much larger worm than *O. mephitis* and the eggs also are larger. The conspicuous seminal receptacle in *O. mephitis* separates it from *O. incisa* which, according to Baer (1927), has only a very small one, and in *O. incisa* the genital ducts pass between the excretory vessels, while in *O. mephitis* they pass dorsal to the excretory vessels. *O. parva* may be distinguished from *O. mephitis* by the testes in the former having a distribution (see table 1) quite unlike that in the latter, and by the cirrus pouch in the former extending well past the excretory vessels; the musculature of the genital atrium of the former also serves to differentiate it from other species. Meggitt (1934) pointed out that the number of testes and the size of the cirrus sac vary, and should, therefore, be regarded as not infallible specific characters. The present writer finds that an accurate count of testes can be made only in young segments before the testes have developed to a size which results in crowding. In *O. mephitis* the writer does not find the variation in the size of the cirrus pouch greater than the normal limits of variation for such a character. It is, therefore, considered a relatively constant character. Meggitt cautioned against accepting unquestioningly the measurements of eggs and oncospheres since they vary according to the medium in which the eggs are measured. The measurements here given are for eggs mounted in balsam.

The characteristic appearance of these specimens is that of thin, nearly translucent worms, with the width usually greatest in the region of the mature segments, and the transition from mature segments to gravid segments so rapid as to seem abrupt.

Discussion of table 1.—Meggitt (1934) considered *O. amphisbeteta* Meggitt, 1924 a synonym of *O. erinacci* Meggitt, 1920, but in the opinion of the present writer both these specific names are probably synonyms of *O. incisa* Raillict, 1899. Joyeux (1927) considered *O. incisa* very similar to *O. erinacei* and described the egg capsules of *O. erinacei* var. *rodentium* as 45μ in diameter with the oncosphere 23μ by 17μ. Marotel (1899) described the egg capsules of *O. incisa* as 45μ in diameter and the egg itself as 35μ by 22μ with the hooks of the embryo as 17μ long. Meggitt (1934) did not give the egg size of either *O. erinacei* or *O. amphisbeteta*. Baer (1927) gave the diameter of the eggs of *O. erinacei* as 15μ, and that of the eggs of *O. amphisbeteta* as 30μ. With such conflicting data it is difficult to come to any conclusion other than that the measurement "15μ" given by Baer is probably a typographical error. The number of testes recorded by Meggitt (1924) for *O. amphisbeteta* is 22 to 24 and for *O. erinacei* is 30 to 50, but it is probable that these were counted in mature segments only, and judging from the variation found by the present writer in young segments of *O. mephitis* in which the testes could be accurately counted, variations from 22 to 50 is not beyond specific limits. It is on the authority of Baer (1927) that *O. amphisbeteta* is described as being without a seminal receptacle and *O. incisa* as having a small one. It seems quite possible, since Meggitt fails to state definitely that the seminal receptacle is absent in *O. amphisbeteta*, that a small one may be present but demonstrable only in sections or in well extended segments. However, Meggitt described *O. erinacei* as being without a seminal receptacle, and since he later came to regard *O. amphisbeteta* as a synonym of *O. erinacei* for the present both species must be considered as lacking this structure.

The specimens of *O. incisa* which were but 10 mm. long were regarded by Baer as a *forma minor*.

The massive musculature of the genital atrium of *O. parva* (Sandground, 1926), Meggitt, 1934, appears to be a specific character which would serve to separate this species from other members of the genus. The specific name *parva* was proposed by Baylis (1929) for a member of the genus *Oochoristica*, but when *Atriotaenia parva* Sandground, 1926 was identified as belonging to the genus *Oochoristica*, it created the necessity of renaming *Oochoristica parva* Baylis, 1929. Dr. Baylis has suggested, in correspondence which the present writer had with him, that if necessary *Oochoristica parva* Baylis, 1929 be renamed *Oochoristica lygosomatis*, and he indicated his willingness to have the new name published by anyone in a position to express a definite opinion that Sandground's species is a member of the genus *Oochoristica*. Since *Oochoristica parva* (Sandground, 1926), Meggitt, 1934 possesses no

characters which serve to separate it from the genus *Oochoristica*, the present writer proposes the new name *O. lygosomatis* for *O. parva* Baylis, 1929.

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ZOOLOGY.—*A new species of amphipod of the genus* Grandidierella *and a new record for* Melita nitida *from Sinaloa, Mexico.*[1]

CLARENCE R. SHOEMAKER, U. S. National Museum. (Communicated by MARY J. RATHBUN.)

In 1923 Mr. W. E. Chapman, American Consul, at Mazatlan, Sinaloa, Mexico, sent some amphipods to the U. S. National Museum which were taken by Mr. Harry Notton in connection with the shrimp investigations which he was carrying on at Mazatlan. The material contained two species, *Melita nitida* Smith, which is reported for the first time from the west coast of America, and a species that I believe to be new to science and which I designate as *Grandidierella nottoni.*

GRANDIDIERELLA Coutière, 1904

The first species of this genus, when described by Giles in 1888, was placed in the genus *Microdeutopus* with which it, however, did not agree by the possession of a uniramous third uropod. Coutière in 1904, when he described his new species, *mahafalensis*, created the genus *Grandidierella* to receive it, and considered its affinities closer to the *Corophiidae*, in which family he placed it. Coutière, and later Stebbing in 1908, called attention to the close alliance of *Grandidierella* with both *Unciola* and *Chevreuxius*, and Stebbing placed his new species, *G. bonnieri*, in the *Corophiidae*. Chilton (1921, p. 549) said, "The

[1] Published by permission of the Secretary of the Smithsonian Institution. Received December 8, 1934.

general resemblance of the animals to *Microdeutopus* and to *Aora* is so great that in my opinion the genus should be placed under the *Aoridae*. The third uropods certainly are one-branched, but I do not consider this sufficient to outweigh the resemblance in all other characters which, as will be seen from the following description, is very close." He lays particular stress upon the resemblance of the first gnathopods of the male, the uropods, and the telson to those of *Microdeutopus*. Schellenberg (1925, p. 164) calls attention to the very indefinite limits of the family *Corophiidae* as established by Stebbing in *Das Tierreich*, and suggests the alteration of the family *Aoridae* to include genera with either biramous or uniramous third uropods in order to include the genus *Grandidierella*.

In comparing *Grandidierella* with the genera now placed under the *Corophiidae*, there appear to be so many characters in common that it seems more natural to include it in this family rather than to alter the *Aoridae* for its reception. *Grandidierella* is depressed, possesses a very strongly developed second antenna in the male, has very small side-plates which are not in continuity, and has the third uropods uniramous. These characters are very strongly emphasized in *Grandidierella elongata* Chevreux (1925, p. 393, fig. 32) and in the present species, and are also possessed by the genera *Corophium*, *Unciola*, and *Siphonoecetes*. *Chevreuxius*, *Ericthonius*, *Neohela*, *and Unciolella* are depressed with small disconnected side-plates, and have uniramous third uropods, but without the strongly developed second antenna. *Camacho* is depressed and has the small disconnected side-plates, but has a minute second ramus to third uropods. *Cerapus* is depressed, has the separated side-plates, and uniramous third uropods, but has the first antennae strongly developed. In the genera *Cerapus*, *Corophium*, *Ericthonius*, and *Siphonoecetes*, the second gnathopods are larger than the first, but in *Neohela*, *Unciola*, *Chevreuxius*, and *Unciolella* the first gnathopods are larger than the second. In the genera *Chevreuxius*, *Unciolella*, and *Grandidierella* the first gnathopod of the male is strongly developed and very similar in structure, the fifth joint being enlarged with a short, transverse palm defined by a strong tooth at the lower distal extremity. The second gnathopods in these three genera are very similar in structure, being weak, slender, and subchelate. In the species of *Grandidierella* here described, besides other points of resemblance, the fifth or last peraeopod and the second antenna of the male bear a very close resemblance to *Corophium;* the fourth and fifth joints of this antenna bearing the characteristic distal tooth of that genus.

Chevreux (1925, p. 392), when describing his species, *G. elongata*, placed it in the family *Corophiidae*.

In view of the foregoing considerations, it would seem more natural to place *Grandidierella* with other closely related genera in the family *Corophiidae* rather than alter the characters of the family *Aoridae* to accommodate it.

Grandidierella nottoni, n. sp.

Male.—Head with lateral lobes well developed and bearing the ill defined, black eye. Antenna 1 with first joint stouter, but a little shorter than second, third joint about one-third the length of second, flagellum nearly

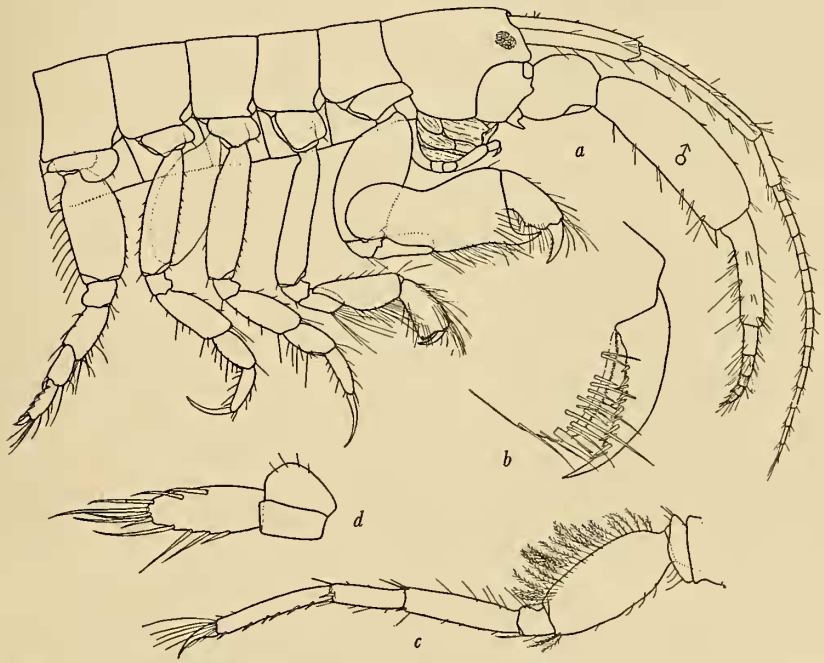

Fig. 1.—*Grandidierella nottoni*, new species, male. *a*, anterior portion of animal. *b*, end of gnathopod 2, greatly enlarged. *c*, peraeopod 5, same scale as *a*. *d*, uropod 3, greatly enlarged.

as long as peduncle and composed of fifteen joints, accessory flagellum minute, about half the length of the first joint of primary flagellum. Antenna 2 robust, but slightly shorter than antenna 1, first and third joints very prominent and strongly developed, fourth joint very strongly developed and nearly twice as long as fifth, flagellum shorter than fifth joint and composed of two long joints and four shorter joints. The fourth and fifth joints of the second antenna of the male bear a distal tooth, thus completing the very close resemblance of this antenna to that of the male *Corophium*. The mouthparts bear a very close resemblance to those figured by Coutière (1904, p. 5, figs. 6–9) for *G. mahafalensis*. Gnathopod 1 is very robust and strong, the fifth joint being produced backward into a very prominent rounding lobe

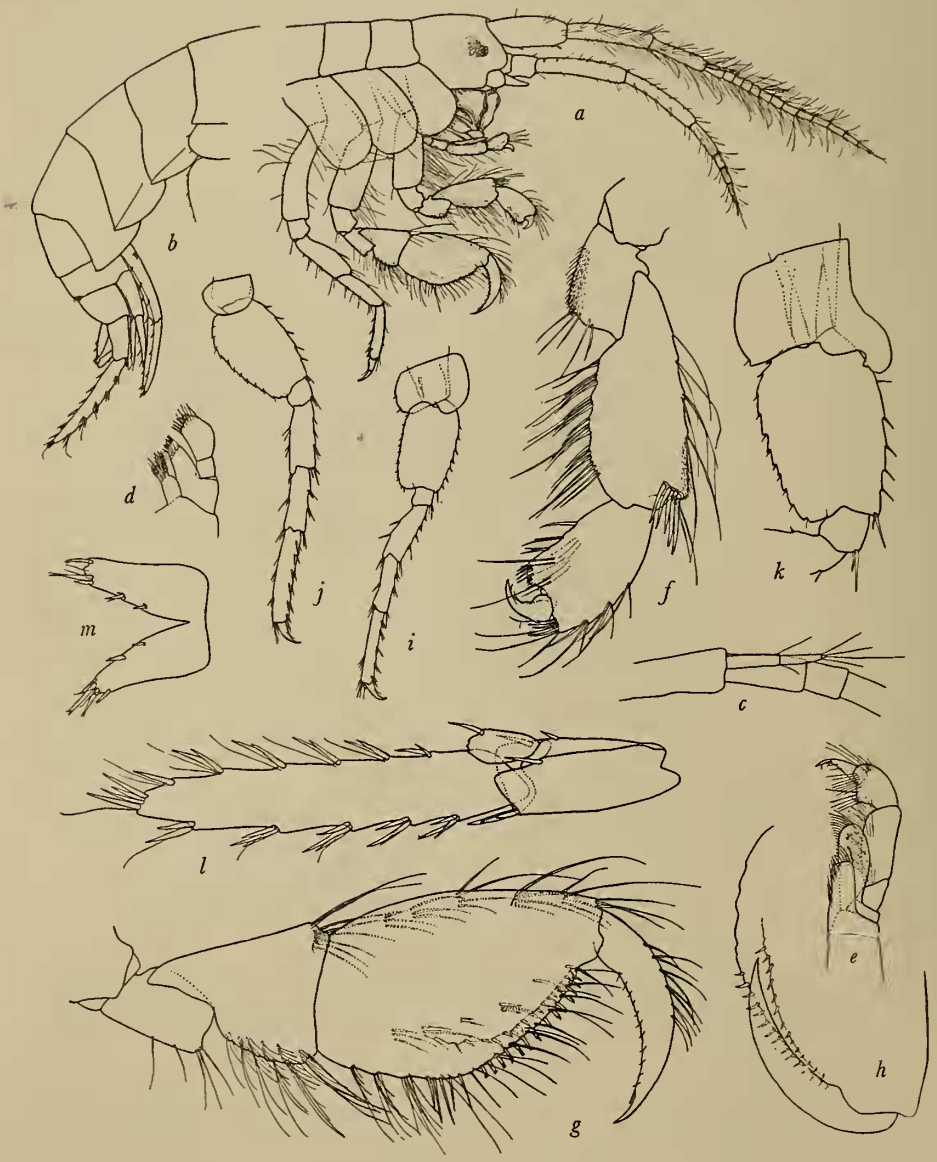

Fig. 2.—*Melita nitida* Smith, male from Mazatlan. *a*, anterior portion of animal. *b*, posterior portion of animal. *c*, accessory flagellum, greatly enlarged. *d*, maxilla 1. *e*, maxilliped. *f*, gnathopod 1. *g*, gnathopod 2. *h*, inside of gnathopod 2 showing shallow groove bounded by spines into which the dactyl fits. *i*, peraeopod 3, same scale as *a* and *b*. *j*, peraeopod 5, same scale as *a* and *b*. *k*, peraeopod 4 of female. *l*, uropod 3. *m*, telson.

much as figured by Chilton (1921, p. 550, figs. 10,n and 10,o) for *G. megnae* but there is not the slightest suggestion of a forward-pointing tooth in the center of the palm either in young or old individuals, nor is the small tooth figured by Chilton (1921, p. 550, fig. 10,e) on the posterior margin of the fifth joint present in any of these specimens from Mazatlan; the prominent tooth on the sixth joint of Chilton's figures (1921, p. 550, figs. 10,n and 10,o) is not present in any of my specimens. Gnathopod 2 bears a close resemblance to Chilton's figure (1921, p. 550, fig. 10,g), except that in the present specimens the second joint is comparatively longer and slenderer and the palm is more nearly transverse. Peraeopods 1 and 2 bear a close resemblance to those of the genera *Microdeutopus* and *Corophium*, but the seventh joint is as long as the sixth, as in *Corophium*. Peraeopods 3 to 5 increasing consecutively in length, peraeopod 5 closely resembling that of *Corophium*, the second joint bearing posterior plumose marginal setae. Side-plates all very shallow, narrower than their respective segments and not in continuity. Pleon segments 1 to 3 with postero-lateral corners broadly rounding. Uropod 1 extending back slightly farther than 2, and the peduncle without a stout spine at distal extremity, as figured by Coutière (1904, fig. 17) for *G. mahafalensis*. Uropod 2 extending back very slightly farther than 3. Telson wider than long, distally truncate, and having a small seta at either lateral corner.

Length.—Male about 7 mm.

The female in general like the male. Antenna 2 not so strongly developed, but the lower lateral margin of the head deeply incised to receive the enlarged first peduncular joint as in the male. The fourth joint of antenna 2 bears on the lower inner margin a distal forward-pointing spine and another similar spine nearer the proximal end. In younger females the distal spine only appears to be present. Gnathopod 1 not much larger than 2 and simply subchelate, the oblique evenly convex distal margin of the sixth joint forming the palm against which the seventh joint exactly fits. Gnathopod 2 like that of the male, though somewhat proportionately shorter. Peraeopods and uropods as in the male. Female about as long as male.

Type.—Male, taken at Mazatlan, Sinaloa, Mexico, February, 1923, by Harry Notton; water brackish, salinity, 13.5 per mill. U.S.N.M. Cat. No. 69742.

Chilton demonstrated that *Grandidierella megnae* (Giles) was subject to great variation in some of its characters, and concluded that *G. mahafalensis* Coutière and *G. bonnieri* Stebbing were synonyms of Giles's earlier species. Later authors have adopted Chilton's view. Recently Dr. Stephensen (1933, pp. 434 and 446) has reported *G. megnae* as being extremely common in shallow salt-water pools, and in cisterns, on the islands of Bonaire and Curaçao off the coast of Venezuela.

As neither young nor old males of the present Mexican specimens show any vestige of a central palmar tooth, nor a tooth on the under side of the sixth joint of gnathopod 1, and as Chilton's figure (1921, p. 550, fig. 10,c) of the second antenna of a mature male does not show the *Corophium*-like development of the present specimens, I have concluded that they represent a new species.

The collection of the U. S. National Museum contains specimens of what I believe to be *G. megnae* (Giles) from two new localities from the West Indian region.

The first lot, consisting of males and females, was taken in February, 1933, by Mr. R. M. Bond from Étang Saumâtre, a brackish lake of Haiti. The largest male, measuring about 5 mm. in length, has in gnathopod 1 only the rudiment of the central palmar tooth, no lower marginal tooth on fifth joint, and no tooth on the under margin of the sixth joint. The largest female with eggs bears on the lower inner margin of the fourth joint of antenna 2 four evenly placed forward-pointing spines. These spines are quite conspicuous, but apparently have not been mentioned in any of the descriptions heretofore.

The second lot consists of three male specimens taken from the stomach of a flounder at Tortugas, Florida during the summer of 1933 by Dr. Harold W. Manter. The largest of the specimens has the first gnathopod nearly as figured by Chilton (1921, p. 550, fig. 10,f). It bears the small central palmar tooth and the small marginal tooth on the lower margin of the fifth joint, but lacks the tooth on the under margin of the sixth joint as does Chilton's. The two smaller specimens bear the central palmar tooth, but not the small tooth on the lower margin. The largest specimen only retains one of the second antennae which appears to be much slenderer than that figured by Chilton (1921, p. 550, fig. 10,a). The first antenna of this male is considerably longer than the second and proportionately much slenderer than that figured by Chilton (1921, p. 550, fig. 10,a). The largest of the specimens measures about 3.5 mm.

As far as we can learn from the published records of the genus *Grandidierella*, it appears to inhabit mainly brackish waters. Tattersall records it from fresh water in China, Stephensen from slightly saline cistern water in Bonaire Island. The specimens from Tortugas, however, were found in the ordinary water of the Gulf of Mexico in the vicinity of the Gulf Stream. The species here described, *G. nottoni*, was taken in brackish water, salinity 13.5 per mill.

MELITA NITIDA Smith

This species was described by Prof. S. I. Smith in 1873 from the coast of New England. Since then it has been reported from widely separated localities along the east coast of the United States as far south as Louisiana, by Paulmier (1905, p. 162), Holmes (1905, p. 505), Pearse (1912, p. 371), Fowler (1912, p. 187), and Kunkel (1918, p. 99).

The present specimens taken in February, 1923, by Mr. Harry Notton are the first to be recorded from the west coast of America. In 1933 Dr. Waldo L. Schmitt, while a member of the Hancock Galapagos Expedition, collected specimens at La Plata Island, Ecuador; Cocos Island, southwest of Costa Rica; and Bahia Honda, Panama.

In west coast specimens the flagellum of antenna 1 is a little shorter than the peduncle and not longer, as Smith (1873, p. 560) records of the New England specimens. The fourth joint of antenna 2 is slightly longer than the second joint of antenna 1 and not scarcely shorter, as stated by Smith. The seventh joint of gnathopod 1 of the male projects inward nearly at a right angle to the sixth joint, as recorded by Smith, but this joint is perfectly developed to fit the palm, so it is probable that the animal has the ability to close it against the palm if necessary. In gnathopod 2 of the male, the dactyl closes against a row of short spines on the inside surface of the sixth joint. As in Smith's specimens, the fifth pleon segment bears posteriorly a row of three or four short spines on either side of the median dorsal line.

In the female the sixth side-plate has the lower front corner produced into a peculiar and characteristic lobe much as that of *Melita palmata* (Montagu).

The largest specimens that I have seen from the west coast of America measure about 6 mm., while Smith gives 7–9 mm. for the New England specimens.

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ENTOMOLOGY.—*A new species of blister beetle from Arizona.*[1]

GUIDO G. MAYDELL.[2] (Communicated by HAROLD MORRISON.)

Epicauta crassitarsis, n. sp.

Reddish pitchy brown, clothed with luteous or cinereoluteous pubescence; on each elytron a whitish longitudinal line. Head black, shining, coarsely but sparsely punctate and clothed with a sparse pubescence; median line distinct; eyes large, feebly emarginate anteriorly, coarsely granulated; antennae dark brown, the first joint enlarged apically, reddish except the apex and provided with rather long cinereous hairs, the second joint with the basal half reddish, the third joint elongated not quite as long as the first two combined, the following decreasing in length and somewhat flattened apically. Prothorax subquadrate, a little longer than wide, parallelsided in three-fourths of the length; median line distinct, punctation and pubescence the same as on the head. Elytra parallelsided, finely punctate-granulate; on each elytron a narrow median line of lighter pubescence not quite reaching the apex; the sutural, apical and lateral margins also whitish. Abdomen and sterna black, the legs reddish, both sparsely clothed with cinereous pubescence. The hind tibial spurs stout, acuminate to the tip. Length 10–11 mm.

Male.—Anterior tibiae with a single short and curved terminal spur. The tarsi of the intermediate legs with the three basal joints bulb-like, enlarged; the first joint the largest and curved in its basal half.

Female.—The anterior tibiae bicalcarate; the tarsi of the intermediate legs normal.

Type.—Male, Tempe, Ariz., Sept. 7, 1933, K. B. McKinney (4–145); 3 paratypes, 1 male, 2 females, labelled in the same way, all in the collection of the U. S. National Museum, Washington, D.C.

[Just before his death a supplementary series of this species, 20 specimens, was received from the same source, but collected by Mr. McKinney on alfalfa Sept. 20, 1934, about a year after the type series above described. Mr. Maydell unfortunately had no opportunity to reconsider his first draft based on only the four above listed types. H. S. B.]

ZOOLOGY.—*New nematodes of the genus* Longistriata *in rodents.*[3]

G. DIKMANS, Bureau of Animal Industry. (Communicated by MAURICE C. HALL.)

Longistriata musculi, n. sp. Figs. 1–7.

Specific diagnosis.—Longistriata: Worms small, with anterior end of body usually coiled in a loose spiral. Cephalic cuticle slightly inflated and marked with annular striations, inflation extending for a distance of 65 to 75μ; beyond this point a cuticular expansion marked by longitudinal striae in-

[1] Received December 3, 1934.

[2] During the few days before his sudden death on September 28, 1934, Mr. Maydell had been adding to his manuscript revision of the Meloid genus *Epicauta* from the data assembled in the U. S. National Museum. The abrupt termination of his labor leaves this revision uncompleted. Among his last written additions the following description of a peculiar southwestern species about which he had spoken with much interest is complete and ready for publication. H. S. Barber.

[3] Received December 11, 1934.

creasing in number from anterior to posterior end. Immediately posterior to cervical inflation longitudinal striae numbering about 6 to 8; in posterior portion striae numbering about 18 to 20, all striae being marked by fine cross striations. Head rounded; mouth and circumoral papillae inconspicuous. Esophagus 320 to 450μ long by 30 to 40μ wide in its terminal portion. Nerve ring near middle of esophagus. Excretory pore near beginning of posterior fourth of esophagus.

Male 3.25 to 4.5 mm. long by 95 to 100μ in maximum diameter immediately anterior to bursa. Bursa relatively large and symmetrical. Ventro-ventral ray shortest and slenderest, and externo-dorsal longest and thickest, of paired rays; remaining paired rays about equal in size; tips of rays approximately equidistant at margin of bursa except for postero-lateral and externodorsal, these rays approximated to each other. Dorsal ray divided into 2 branches in its distal third, each branch again dividing near tip, external branch of second bifurcation longer than inner branch. Spicules 390 to 420μ long, straight and filiform, with triangular enlargement at distal ends. Gubernaculum absent.

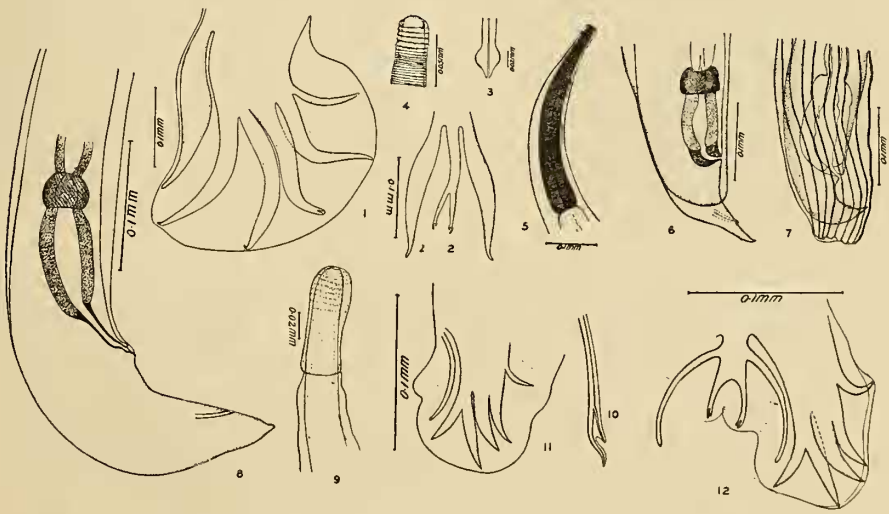
Female 4.25 to 6.75 mm. long and about 100 to 160μ wide in region of proximal portion of ovejector. Ovejector single, stout, muscular, about 100μ long. Vulva to anus, 90μ; anus to tip of tail, 30μ. Eggs 55 to 60μ long by 30 to 32μ wide.

Host.—*Mus musculus.*

Location.—Small intestine.

Locality.—Jeanerette, Louisiana, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection No. 30456.



Figs. 1–7.—*Longistriata musculi.* Fig. 1. Lateral view of bursa. Fig. 2. Dorsal rays of bursa. Fig. 3. Terminal portion of spicules. Fig. 4. Anterior portion of head. Fig. 5. Anterior portion of body. Fig. 6. Posterior portion of body of female, showing ovejector. Fig. 7. Posterior portion of body of female, showing longitudinal striations of cuticle.

Figs. 8–12.—*Longistriata norvegica.* Fig. 8. Posterior portion of body of female, showing ovejector. Fig. 9. Anterior portion of body, showing cuticular inflation. Fig. 10. Terminal portion of spicule. Figs. 11 and 12. Bursa.

Longistriata norvegica, n. sp. Figs. 8–12.

Specific diagnosis.—Longistriata: Worms small, usually coiled in a loose spiral. Cervical inflation characteristic of this group of nematodes, about 75 to 80μ long by 25 to 30μ wide, the anterior widest portion marked by annular striations. Width of head, exclusive of inflation, about 16μ. Cuticle of body inflated and marked by longitudinal striae, each striation showing cross striations. Esophagus 275 to 300μ long and 20 to 25μ wide in its distal portion. Nerve ring about 150 to 175μ, and excretory pore about 20 to 27μ, anterior to termination of esophagus.

Male about 4 to 4.5 mm. long by 45 to 50μ wide just anterior to bursa. Cuticular inflation extending on ventral side of body to within 30 to 35μ anterior to commencement of bursa. Bursa symmetrical, with 2 lateral lobes and 1 dorsal lobe. Spicules 350 to 375μ long, filiform, distal ends divided into 2 branches enclosed in a sheath. Gubernaculum absent. Ventro-ventral ray shortest and slenderest of the paired rays, directed forward and widely separated from latero-ventral ray. Latero-ventral, externo-lateral and medio-lateral rays of about equal thickness and length, the first 2 being parallel and diverging only slightly in their distal portions; externo-lateral the thickest ray; medio-lateral ray the longest ray and directed straight towards margin of bursa. Postero-lateral ray originating from a common stem with medio-lateral and directed dorsally; these two rays widely separated at their tips. Externo-dorsal rays and dorsal ray originating from a common stem, the former being very slender and curving outward from dorsal; stem of dorsal very wide and bifurcating at middle; each branch divided at tip, outer branch longer than inner. None of rays reaching margin of bursa.

Females 5 to 5.5 mm. long and about 90μ wide in region of vulva. Single ovejector, including sphincter, about 100μ long by 40μ wide. Vulva about 100μ from anus; anus about 30μ from tip of tail; tip of tail narrowing abruptly about 5μ from end and terminating in a conical, blunt point. Eggs 60 to 65μ long by 30 to 35μ wide.

Host.—Rattus sp.

Location.—Small intestine.

Locality.— Jeanerette, Louisiana, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection No. 30457

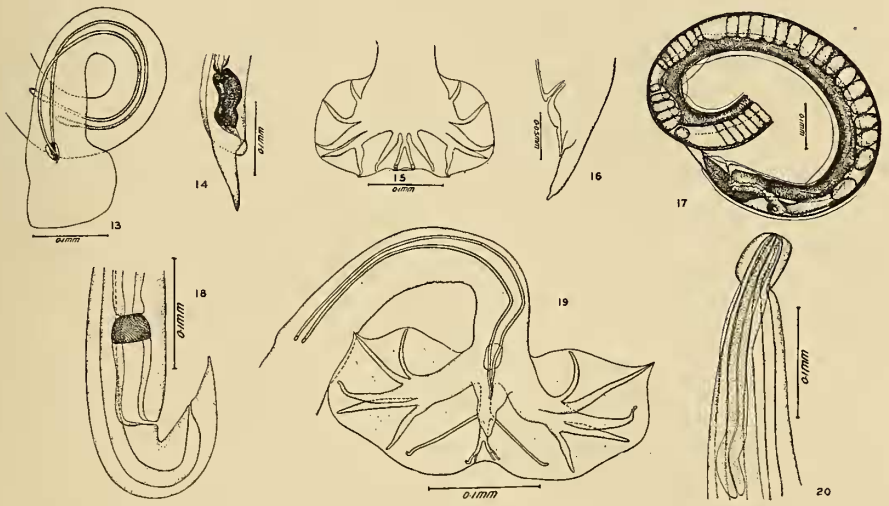
The nematode here described under the name of *Longistriata norvegica* is very similar to the nematode described by Chandler (2) as *Longistriata adunca* from the cotton rat, *Sigmidon hispidus*. Chandler, however, described an accessory piece or gubernaculum as being present in the nematode described by him. No such structure has been observed in the nematode described here as *Longistriata norvegica*. The writer, therefore, must accept Chandler's description as correct, pending some reexamination of his material or a comparative study of these two nematodes.

Longstriata carolinensis, n. sp. Figs. 13–17.

Specific diagnosis.—Longistriata: Worms small, usually rolled in a loose spiral. Cervical inflation about 50μ long by 30μ wide. Cuticle of body inflated and marked with distinct longitudinal striations or bands, these in turn distinctly marked with cross-striations. Head rounded, mouth opening and circumoral papillae inconspicuous. Esophagus 280 to 310μ long by 35 to

40μ wide in its terminal portion. Excretory pore about 120μ anterior to termination of esophagus. Nerve ring slightly anterior to excretory pore.

Male 2.7 to 3 mm. long and 70 to 80μ in maximum diameter immediately anterior to bursa. Bursa symmetrical, 125 to 130μ long and 225 to 250μ wide when fully expanded. Ventro-ventral rays short and slender, directed forward; latero-ventral ray widely separated from and somewhat larger than ventro-ventral ray and also directed forward; externo-lateral, thickest of the paired rays, widely separated from latero-ventral, but parallel to medio-



Figs. 13–17.—*Longistriata carolinensis.* Fig. 13. Posterior portion of male, showing spicules and gubernaculum. Fig. 14. Posterior portion of female, showing ovejector. Fig. 15. Bursa. Fig. 16. Posterior portion of female, showing relative positions of vulva and anus. Fig. 17. Posterior portion of female.

Figs. 18–20.—*Longistriata dalrymplei.* Fig. 18. Posterior portion of female, showing ovejector. Fig. 19. Posterior portion of male, showing bursa and spicules. Fig. 20. Anterior portion showing cuticular inflation.

lateral except at tip, here the latter two rays diverging slightly, externo-lateral bending ventrad and medio-lateral running straight toward margin of bursa; postero-lateral ray originating from medio-lateral ray and directed posteriorly to margin of bursa, the tips of these rays widely separated, all these rays reaching margin of bursa. Externo-dorsal rays originating separately from dorsal ray; dorsal ray divided into rather long branches, each of these bifurcated at tip; branches of bifurcation equal in size. Spicules 400 to 450μ long, filiform, with expanded proximal ends. Gubernaculum about 25μ long by 15μ wide.

Female about 3.5 mm. long. Ovejector single, about 80μ long. Vulva 60 to 65μ from anus; tip of tail 40 to 50μ from anus. Tail narrowing abruptly shortly before its termination and ending in a blunt point. Eggs 58μ long by 30 to 35μ wide.

Hosts.—*Peromyscus maniculatus* (Deer mouse), and *Microtus ochrogaster* (Prairie meadow mouse).

Location.—Small intestine.

Localities.—Great Smoky Mountains, North Carolina, and Vincennes, Indiana, U. S. A.

Type specimen.—U. S. National Museum Helminthological Collection No. 30458.

Longistriata dalrymplei, n. sp. Figs. 18–20.

Specific diagnosis.—*Longistriata:* Worms small, delicate, usually rolled in a loose spiral. Cervical inflation 45 to 60μ long by 27 to 43μ wide. Cuticular inflation with prominent longitudinal lines marked with cross-striations. Esophagus about 250 to 300μ long and 20 to 25μ wide in its terminal portion. Position of nerve ring and excretory pore not determined owing to condition of specimens.

Male 3.7 to 4 mm. long and 40 to 50μ wide in maximum diameter. Bursa symmetrical, about 125μ long and 300μ wide when fully expanded. Ventro-ventral ray directed forward and widely separated from latero-ventral ray at the tip; latero-ventral ray slender and pointed, directed ventrad and extending to margin of bursa; externo-lateral thickest of bursal rays, directed toward lateral margin of bursa, but bending slightly forward before reaching margin. Medio-lateral ray straight and directed toward margin of bursa; postero-lateral ray originating from medio-lateral ray and directed dorsad, tips of two latter rays far apart. Externo-dorsal ray slender, originating from dorsal ray 30μ from its base; dorsal ray about 75μ long, dividing into 2 branches about 20μ from distal end, each branch bifurcating at the tip; outer secondary branch longer than inner branch. Spicules straight, filiform, 340 to 360μ long. Gubernaculum small, almost colorless, about 25 to 30μ long by 15μ wide. Genital cone well developed and prominent.

Female 4 to 4.7 mm. long, and 70 to 80μ in maximum diameter in region of ovejector. Ovejector single, well developed, about 100μ long. Vulva to anus, 50 to 60μ; anus to tip of tail, 40 to 60μ. Tail ending in a sharp point. Eggs 55 to 65μ long and 35 to 40μ wide.

This nematode closely resembles *Longistriata vexillata* (Syn. *Heligmosomum vexillatum* Hall, 1916). It differs from the latter in the possession of a gubernaculum, in the absence of spurs on the dorsal ray between the origin of the externo-dorsal rays and the bifurcation, and in the absence of maculae on the bursal membrane.

Hosts.—*Ondatra zibethica* (Muskrat) and *Microtus pennsylvanicus* (Meadow mouse).

Location.—Small intestine.

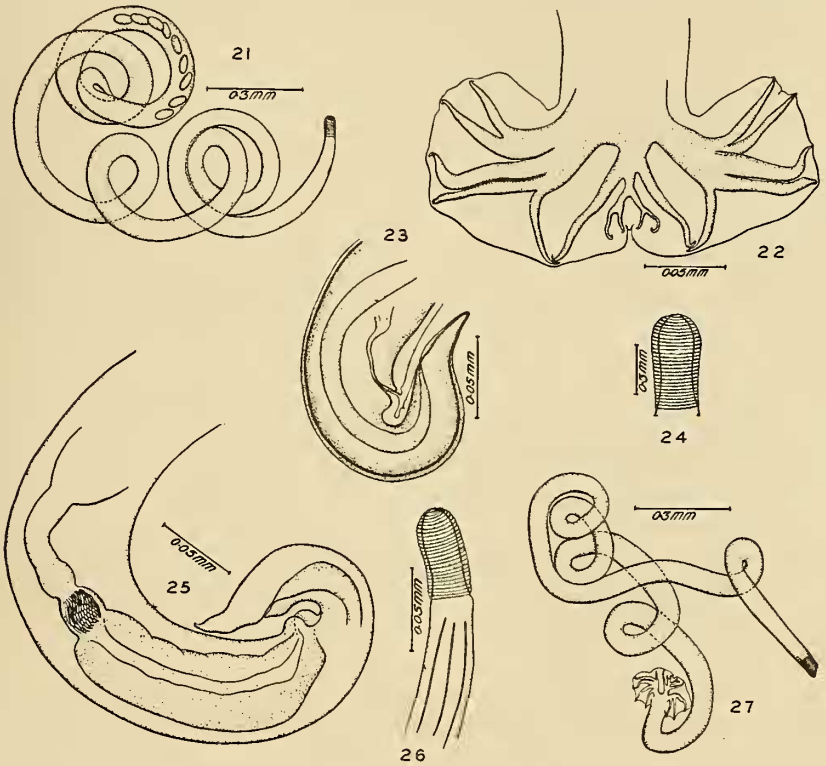
Localities.—New Jersey, Indiana, and Minnesota, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection No. 30459.

Longistriata noviberiae, n. sp. Figs. 21–27.

Specific diagnosis.—*Longistriata:* Worms small, delicate, spirally coiled, bright red in color when freshly collected. Cephalic cuticle slightly inflated, showing distinct transverse striations; inflation 45 to 60μ long by 25 to 30μ wide. Cuticle of body inflated, showing longitudinal striae marked with cross-striations. Esophagus 270 to 300μ long by 25 to 32μ wide near its termination. Nerve ring 165 to 175μ from anterior end. Excretory pore situated from 15μ anterior to 25μ posterior to termination of esophagus.

Male 4 to 5 mm. long by 55 to 65μ in maximum diameter. Bursa symmetrical, about 130 to 150μ long and 240 to 260μ wide when expanded. Ventral rays of approximately the same size, divergent at tips and directed forward, reaching margin of bursa; latero-ventral ray terminating in a slight projection on bursal margin; externo-lateral and medio-lateral rays close together and parallel for greater part of their length, diverging near



Figs. 21–27.—*Longistriata noviberiae.* Fig. 21. Female. Fig. 22. Bursa. Fig. 23. Terminal portion of female. Figs. 24 and 26. Anterior portion of body, showing cervical inflation. Fig. 25. Posterior portion of female, showing ovejector. Fig. 27. Male.

their termination; externo-lateral ray bending sharply ventrad, and medio-lateral ray continuing straight to bursal margin; postero-lateral ray originating from medio-lateral ray, diverging sharply from latter, and directed dorsad, reaching posterior margin of bursa, tips of these two rays widely separated; externo-dorsals originating from a common stem with the dorsal ray and approaching posterior margin of bursa in close proximity to termination of postero-lateral rays; dorsal ray bifurcated, forming 2 fairly widely divergent branches, the latter also bifurcating to form 2 terminal branches. Bursal margin slightly indented in region of dorsal ray. Spicules slender, filiform and equal, 420 to 430μ long. Gubernaculum present, about 35μ long by 15μ wide.

Female 5.5 to 6.5 mm. long by 75 to 80μ wide in region of vulva. Tail pointed and bent sharply ventrad in all specimens examined. Vulva with 2

prominent lips, about 100 to 120μ from tip of tail; anus 45 to 55μ from tip of tail. Ovejector single, about 165μ long. Eggs 70 to 75μ long by 35 to 40μ wide.

Host.—Rabbits (probably *Sylvilagus floridanus alacer* and *Sylvilagus palustris littoralis*).

Location.—Small intestine.

Locality.—Jeanerette, Louisiana, U. S. A.

Type specimens.—U. S. National Museum Helminthological Collection No. 30460.

THE GENUS LONGISTRIATA

In their key to the genera of the family Heligmosomidae, Yorke and Maplestone (1926), regard the spiral rolling of the body as a generic character, and on the basis of that character they separate the genera *Heligmosomum* and *Viannaia*. The acceptance of this feature as a character of generic value has led to confusion and has resulted in the inclusion in the genus *Viannaia* of nematodes which obviously do not belong to it. Schulz (4) proposed, therefore, the subgenus *Longistriata* in the genus *Viannaia* to include those nematodes in which the body is spirally rolled as in *Viannaia*, and in which there are comparatively long spicules and a cuticle distinctly marked with longitudinal striations as in *Heligmosomum*. Travassos and Darriba (6), after noting that the spiral rolling of the body cannot be considered as a distinguishing character, raised Schulz's subgenus *Longistriata* to the status of a genus, with *Longistriata depressa* (=*Strongylus depressus* Dujardin, 1845) as type, transferred several nematodes placed by Travassos (1921) in the genus *Heligmosomum* to the genus *Longistriata*, and made the genus *Heligmonella* Monnig, 1927, a synonym of the genus *Viannella* Travassos, 1918.

The genus *Heligmonella* was created by Monnig (3) with the following diagnosis: "Heligmosominae: body red, spirally coiled, cuticle with marked longitudinal striations; cephalic cuticle inflated and transversely striated. Male: bursa with ventral rays separate and diverging, postero-lateral diverging from externo- and medio-lateral, externo-dorsal arises from a common dorsal trunk, dorsal bifurcated near its extremity, the branches also bifurcated; spicules slender, gubernaculum distinct. Female: vulva near anus, a single uterus. Parasites in stomach and intestine of rodents."

The genus *Heligmonella* differs, therefore, markedly from the genus *Viannaia* in the character of the spicules and in the course and direction of the bursal rays, and its proposed inclusion in the genus *Viannaia* appears to be unwarranted. The genera *Longistriata* and *Heligmonella* resemble each other in the possession of (1) transversely striated cephalic inflation, (2) an expanded and longitudinally striated cuticle, (3) comparatively long and slender spicules, and (4) comparably directed bursal rays, and on the basis of these resemblances the genus *Heligmonella* is here made a synonym of the genus *Longistriata*.

Baylis (1) described a number of new species in the genus *Heligmonella*. These species also are here transferred to the genus *Longistriata*.

It is recognized that the nematodes described in this paper as *Longistriata musculi*, *L. norvegica* and *L. carolinensis*, while resembling other members of the genus *Longistriata* in the possession of an inflated and transversely striated cephalic cuticle, an expanded and longitudinally striated body cuticle, and long and slender spicules, differ from each other and from other members of this genus in the character and direction of the bursal rays, and that their inclusion in this genus may seem to be unwarranted. However, since only a limited amount of material was available for study it was not considered desirable to create new genera for them at the present time.

Heligmostrongylus hassalli Price, 1928, also is here placed in the genus *Longistriata* because in all other species of the genus *Heligmostrongylus* the dorsal ray is completely doubled and in *Heligmostrongylus hassalli* this feature is absent.

The generic diagnosis is amended as follows:

LONGISTRIATA

Generic diagnosis.—Heligmosomidae: Body more or less strongly rolled in a spiral. Cephalic cuticle inflated, marked with annular striations. Cuticle of body expanded and distinctly marked with transversely striated longitudinal lines, continuous or interrupted at intervals. Bursa symmetrical or asymmetrical, with well developed single bifurcated dorsal ray. Spicules comparatively long and slender. Gubernaculum present or absent. Female with well developed single ovejector close to posterior end of body. Vagina short. Vulva close to anus.

Type species.—*Longistriata depressa* (Duj., 1845).

KEY TO SPECIES OF LONGISTRIATA

1. Gubernaculum present and well developed.....2
   Gubernaculum absent or rudimentary.....16
2. Longitudinal striae interrupted at regular intervals.....*L. hassalli*
   Longitudinal striae continuous.....3
3. Gubernaculum asymmetrical.....*L. seurati*
   Gubernaculum symmetrical.....4
4. Spicules 1 mm. long.....*L. monnigi*
   Spicules varying in length from 230 to 450μ.....5
5. Dorsal margin of bursa deeply indented.....*L. cristata*
   Dorsal margin of bursa only slightly indented or without indentation..6
6. Externo-dorsal rays originating separately from dorsal ray.....
   .....*L. carolinensis*
   Externo-dorsal rays originating from a common stem with the dorsal ray.....7
7. Bursa asymmetrical.....8
   Bursa symmetrical.....9

8. Bursa large, 500 to 600μ wide; branches of dorsal ray close together and each provided with 2 terminations..... *L. streptocerca*
   Bursa about 250μ wide; branches of dorsal ray fairly wide apart and each provided with 3 terminations..... *L. trifurcata*
9. Branches of dorsal ray as long as or longer than main stem. *L. intermedia*
   Branches of dorsal ray shorter than main stem.....10
10. Externo-dorsal rays very slender..... *L. dalyrmplei*
    Externo-dorsal rays comparatively stout.....11
11. Terminal branches of dorsal ray equal..... *L. wolgaense*
    Terminal branches of dorsal ray unequal.....12
12. Males 2.6 to 3.25 mm. long; females 3.4 to 3.9 mm. long.....13
    Males 3.8 to 5.5 mm. long; females 5.5 to 9.2 mm. long.....14
13. Spicules 400μ long by 4 to 5μ wide; vulva 120μ from tail end. *L. affinis*
    Spicules 230 to 280μ long by 2.5μ wide; vulva 150μ from tail end..... *L. gracilis*
14. Spicules 270 to 360μ long; vulva 150μ from tail end..... *L. impudica*
    Spicules 410 to 430μ long; vulva either 120μ or 165μ from tail end....15
15. Spicules 410μ long; vulva 165μ from tail end; ovejector 310μ long..... *L. spira*
    Spicules 420 to 430μ long; vulva 120μ from tail end; ovejector 165μ long..... *L. noviberiae*
16. Dorsal ray with accessory branch..... *L. vexillata*
    Dorsal ray without accessory branch.....17
17. Stem of dorsal ray 20μ wide..... *L. norvegica*
    Stem of dorsal ray 5 to 15μ wide.....18
18. Externo-dorsal rays largest of bursal rays; distal ends of spicules enlarged..... *L. musculi*
    Externo-dorsal rays larger than some and smaller than other bursal rays; distal ends of spicule not enlarged.....19
19. Spicules 600 to 800μ long.....20
    Spicules 340 to 560μ long.....22
20. Dorsal ray doubled for more than half its length..... *L. nematodiriforme*
    Dorsal ray divided into 2 branches, each less than half the length of dorsal ray.....21
21. Externo-dorsal ray very slender; inner branch of terminal bifurcation of dorsal ray with slight projection..... *L. didelphe*
    Externo-dorsal ray stout; inner branch of terminal bifurcation of dorsal ray without projection..... *L. alpha*
22. Terminal branches of dorsal ray not divided..... *L. gamma*
    Terminal branches of dorsal ray divided.....23
23. Terminal branches of dorsal ray equal..... *L. delta*
    Terminal branches of dorsal ray unequal, outer branch longer. *L. beta*

Longistriata adunca Chandler, 1932, is similar to *L. norvegica*, differing only in the presence of a gubernaculum described for *L. adunca*.

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BOTANY.—*Certain Desmonci (Palmae) of Central America and Mexico,*[1] H. H. Bartlett, University of Michigan.[2]

The genus *Desmoncus* provides one of the characteristic features of tropical American vegetation. It is often remarked that in the western hemisphere the *Desmonci* take the place of the far more viciously armed climbing palms of the Oriental tropics, such as *Calamus* and *Daemonorops,* which are systematically not closely related, but in their climbing habit, armature, and ecological relations offer some points of resemblance.

To secure specimens of the climbing palms takes much of a collector's time and effort, since they are often not found in fertile condition or easily secured even if found, because of their spininess and difficulty of disengaging them from the limbs of the trees through which they clamber. Good specimens are therefore disproportionately rare in our herbaria, in consideration of their importance in the composition of the tropical forest. Many of the described species are inadequately known, and it has become customary to use a few names as catch-alls for very distinct plants.

It appears that the species of *Desmoncus* are in reality rather local in distribution, and that much careful work on the part of collectors and herbarium botanists will be required to ascertain their ranges and characteristics.

In British Honduras and Guatemala the writer came in contact with a group of *Desmonci* related to *D. chinantlensis* Liebm., which

[1] Received November 20, 1934.

[2] Papers from the Department of Botany and the Herbarium of the University of Michigan, no. 508.

was described from Mexico and remains very inadequately known. These related plants of northern Central America are called "basket tie-tie" or "basket whist" by the inhabitants of British Honduras and "bayal" by the Spanish-speaking people and the Maya. In British Honduras any vine is a "tie-tie," and the *Desmonci* are the particular "tie-ties" of which baskets are made—whence the name.

Either there are many local species with rather slight distinctions, as the writer believes, or else there is a very wide-spread species, *Desmoncus chinantlensis* Liebm., made up of a group of varieties, or (as some botanists might even conclude) of taxonomically negligible variations. Several of these minor species are here described. There are indications in the herbaria that other species of the same order of distinctness remain to be described, but unfortunately entirely satisfactory material is lacking.

In addition to the species related to *D. chinantlensis* there are others farther south in Central America which have quite different relationships. It is evident that the alliance of *D. chinantlensis* does not hold the field alone much south of Guatemala, although Bailey[3] found a species in Panama which he has tentatively referred to it.

There is some question as to the interpretation of Liebmann's *D. chinantlensis* which might best be cleared up by renewed collecting and study at the type locality. Bailey refers to a sheet at Copenhagen as the type specimen (Liebmann no. 6595), and remarks that it does not agree with two specimens in the United States National Herbarium (Liebmann nos. 6594 and 6596). Since the original description (Martius, Historia Palmarum 3: 321. 1850) cites no specimen whatever, it seems best to typify the species by a specimen or specimens conforming as closely as possible with the original description, and from this standpoint the specimens in the United States National Herbarium may be fairly viewed as cotypes. I have considered them as such in my interpretation of the species. The justification for so doing lies in the fact that the *Desmoncus* from Barro Colorado Island, Panama, which Bailey figures and which agrees with the particular Liebmann specimen (no. 6595) that he regards as the type of *D. chinantlensis*, does not conform to the original description. It appears to lack the beard of spines on the upper side of the base of the leaflet, which is characteristic of the entire alliance of *D. chinantlensis*, and which Liebmann refers to in the description ("*pinnis . . . antice juxta nervum aculeatis*"). Bailey's Barro Colorado plant also agrees with Liebmann's no. 6595 in having "thin, not stiffly veined glabrous pin-

[3] Bailey, L. H. *Certain palms of Panama.* Gentes Herbarum 3: 31–116. 1933.

nae 8 inches or less long." On the contrary, the two Liebmann specimens in the National Herbarium have, as Bailey says, "different looking, very costate pinnae and much smaller spines." Referring again to Liebmann's original description, we find that the lower leaflets should be 9 inches long, not 8 *or less*, and that the pinnae should be strongly plicate (*"pinnis . . . valde plicatis"*) rather than "thin, not stiffly veined." Furthermore, Liebmann describes a type with dimorphic spines on the petioles and lower rhachis, and with the leaflets irregularly aggregated, whereas Bailey's species, which agrees with Liebmann 6595, has (according to the figure) spines of a single type and pinnae "mostly opposite or subopposite." In view of the discrepancies between Bailey's plant and the Liebmann description of *D. chinantlensis*, I have preferred to interpret the latter as being really represented by Liebmann's nos. 6594 and 6596 in the United States National Herbarium.

The entire alliance of *Desmoncus chinantlensis* lacks hooked prickles, has a beard of *aciculae* on the upper surface of the leaflet near the base, and is presumably characterized by nine rather than six stamens, although not all of the species are known from flowering specimens. Leaving out a couple of species which are doubtless distinct, but of which the material is inadequate for description, the group may be arranged as follows:

Corolla of female flower containing at one side of the ovary a fimbriate, oblong, basally attached scale as long as the corolla lobes; leaflets only about 1 cm. broad. . . . . *D. anomalus*

Corolla of female flower containing no such scale; leaflets over 2.5 cm. broad.

Axis and branches of inflorescence thick and somewhat fleshy. . . . . *D. chinantlensis*

Axis and branches of inflorescence thin, not fleshy.

Rhachis even if short-aciculate also armed below the middle with a few distant retrorse or subretrorse spines which are the longest ones on the plant.

Inferior spathe aciculate: female flowers with annuliform-cupulate calyx, very obtusely 3-apiculate and corolla broader than high, nearly evenly truncate, but sharply though minutely 3-apiculate. . . . . *D. Lundellii*

Inferior spathe entirely or nearly unarmed: female flowers with acutely triangular-cupulate calyx and corolla higher than broad with margin 3-apiculate from deep rounded sinuses. . . . . *D. quasillarius*

Rhachis sparsely to densely aciculate with spines no longer than those on other parts of the plant, and not clearly dimorphic.

Inferior spathe almost unarmed.....*D. uaxactunensis*
Inferior spathe aciculate: corolla of female flower broader than high, obtusely 3-apiculate with shallow obtuse sinuses.....*D. ferox*

Desmoncus anomalus sp. nov.

Scandens pergracilis. Vaginae pars superior (ochrea) 12 mm. diam., 22 cm. longa albida, cinnamomeo-furfuracea, subappresse aciculata, aciculis majoribus 8 mm. longis, juventate ferrugineo-pubescentibus. Petiolus 1.5 cm. longus, debiliter et breviter aciculosus. Rhachis petiolo similis 165 cm. longa subtus subinermis, furfuracea, supra sparsim armata, aciculis majoribus 12 mm. longis. Foliola utrinque ca. 19, basi debiliter aciculata inferiora ca. 22 cm. longa, 7 mm. lata in filum attenuata; mediocria ca. 21 cm. longa, 10–12 mm. lata; superiora 24 cm. longa, 8 mm. lata, caudato-acuminata. Foliolorum paria intermedia in uncos transeuntia reflexa, ca. 14 cm. longa, 2 mm. lata. Uncorum paria 10 debilia, inferiora ca. 12 cm. inter se distantia, 6 cm. longa, superiora 1.5 cm. distantia, 2.5 cm. longa. Cirrhus omnino inermis. Spatha inferior 28 cm. longa, 14 mm. lata, sparsissime breviterque appresso-aciculata. Rami fertilis pars inter spathas 29 cm. longa, 10 mm. lata, compressa, sparsim appresso-aciculata. Spatha superior deest. Pedunculus 6 cm. longus, aciculas 4–10 mm. longas ferens. Rhachis ramifer 20 cm. longa, albida, sparse ferrugineo-furfuracea; ramis floriferis ca. 35 valde flexuosis, inferioribus 12 cm. longis. Flores inferiores terni, bracteolis 1 vel 3 firmis brevissimis anguste lunulatis vel canaliculiformibus apiculatis subtenti. Flores feminei centrales; gamopetali et gamosephali. Calyx subannuliformis vel circumscriptione rotundato-triangulus, angulis obtusissimis rotundatis. Corolla (solum vetusta fructibus delapsis visa) obtusissime apiculata, unilateraliter includens squamam lobis corollae 2.2 mm. longis propriis aequilongam et 2 mm. latam apice fimbriatam. Staminodia vestigialia basi corollae connata. Pistillum et fructus desunt. Flores masculi omnes delapsi sed eorum cicatrices in ternis inferioribus laterales et in ramorum apicibus singuli.

Specimen typicum in U. S. Nat. Herb. in Guatemala legerunt *O. F. Cook* et *C. B. Doyle*, no. 97, ad Secanquim, in Alta Vera Paz.

Desmoncus Lundellii sp. nov.

Scandens caule sursum vaginis tecto 2.5 cm. diam. nudato ca. 1.7 cm. Folia caulem imbricate vaginantia. Vaginae supra petioli insertionem in ochream apice in fibros dissolutam 18 cm. longam productae, pallide griseo-cinnamomeae, aciculis ex papillis anguste conicis vel subcylindricis orientibus, subascendentibus atris juventate sordide furfuraceo-pubescentibus, longioribus 16 mm. longis dense armatae. Petioli pars libera 2 cm. longa 12 mm. lata et rhachis pars basalis subtus sparsim supra densius aciculatis cum duarum aciculis specierum aut pergracilibus ca. 6 mm. longis aut validis 3.5–5 cm. longis. Rhachis ca. 1.75 m. longa foliolis utrinsecus ca. 20, lanceolatis, acutis, gregatim alternis, infimis ca. 17 cm. longis 2.5 cm. latis; mediis ca. 32 longis 3.4 cm. latis; supremis 26 cm. longis, 3.0 cm. latis; transitionalibus retroflexis 1-jugis 14 cm. longis 4.5 mm. latis; amnibus longitudinaliter subplicatis ca. 20-venosis utrinque obscure transverse venulosis, supra prope basin horride aciculatis, aciculis ca. 20–30, longioribus 3.0–4.0 cm. longis, subascendentibus, etiamque in venae mediae tertia parte basali aciculas 2–4 ferentibus. Cirrhus sparsim longiaciculatus uncos jugatim ferens, basi valde incrassatos, lateraliter compressos, rigidos,

majores 3.5 cm. longos, secus rhachin 11 cm. separatos; intermedios 2.5 cm. longos, 7 cm. separatos; ultimos non visos. Spatha inferior fere glabra apice sparse et appresse breviaciculata. Spatha superior fusiformis 22–30 cm. longa, 3–4 cm. diametiens, dense armata, aciculis atris rectis diverse directis majoribus ca. 12 mm. longis. Pedunculus 4–10 cm. longus aciculis subascendentibus vestitus. Inforescentiae pars ramosa 18–20 cm. longa, solum ad basin aciculata ramis simplicibus ca. 30, longioribus 10 cm. longis, hand carnosis valde acutangulatim contortis vel flexuosis. Flores superiores solitarii staminei sessiles bracteolis rigidiusculis subretroflexis .5–1.0 mm. longis subtenti, ex calyce membranaceo gamosepalo, corolla longe pyramidato tripetala et staminibus (9?) constituti, calyce excentrico, horizontaliter 3.3 mm. lato (si applanato), longitudinaliter 2.3 mm. diametiente; petalis carnosis, deltoideis 9 mm. longis, longe acutis. Flores inferiores terni unus femineus medius alii 2 staminei (delapsi) lateraliter et superiuscule positi et bracteolis minutis triangulis subtenti. Floris feminei calyx symmetricus membranaceis 3 mm. diam. annuliformis apices subobsoletos sepalorum unitorum obtusissimos obscure exhibitantes. Corolla carnosa sympetala cyathiformis 2.8 mm. diam. 2.5 mm. alta, margine minutissime triapiculata. Stamina vel staminodia nulla. Ovarium unilocularium ellipsoideum apice acuto breviter 3-stigmatosum. Fructus ovoideus 13 mm. longus, 11 mm. diametiens, pericarpio tenui carnoso, endocarpio osseo paululum supra aequatorem foraminibus 3, placentis parietalibus oppositis, perforatis.

Specimen typicum in Herb. Mich. legit *C. L. Lundell* prope El Paso de Petén, Petén, Guatemala, 26 Apr. 1932.

Desmoncus quasillarius sp. nov.

Scandens, caule vaginato ca. 3 cm. crasso. Vaginae pars supra petioli insertionem (ochrea) ca. 15 cm. longa, apice in fibros dissoluta, griseo-cinnamomea, aciculis atratis plerumque quam 1 cm. brevioribus modice tecta. Petiolus 22 mm. longus minus aciculatus quam ochrea. Rhachis ca. 1.9–2.0 m. longa, tenuiter ferrugineo-furfuracea, supra aciculas specierum duarum ferens, paucas compressas fere 14 mm. longas et alias breviores, omnes patentes vel subascendentes; subtus solum infra medium spinas longiores pauciores retroflexas 2 cm. longas validas ferens, sursum in cirrhum omnino inermem transeuns. Foliola subplicata, glabra, utrinsecus ca. 22, inferiora irregulariter aggregata, superiora pariter subalterna vel subopposita; infima 23 cm. longa, 14 mm. lata, supra ad basin barbatim aciculata, aciculis ca. 6–10 longioribus 15 mm. longis, apice longe attenuata, et subtus, caudam apicalem versus, acicula solitaria 13 mm. longa instructa; media ca. 30 cm. longa, 3 cm. lata acuminata ad basin minus barbata, solum 4–6 aciculas, longiores ca. 20 mm. longas, ferentia; suprema 24 cm. longa, 32 mm. lata, basi et apice longe angustata, leviter barbata, aciculas solum 1–3 breves ferentia. Foliola 2 transeuntia in uncos recurvata base incrassata non barbata 18.5 cm. longa 18 mm. lata. Uncorum paria 9 infima 7 cm. longa, inter se 10 cm. distantia, sequentia gradatim breviora et propinquantia. Spatha inferior inermis vel sparsissime et breviter aciculata, ca. 14–18 mm. lata; pars aperta ca. 7 cm. longa. Ramus fertilis infra spatham superiorem sparse et breviter aciculatus. Spatha superior fusiformis ca. 27 cm. longa, 22 mm. crassa, deorsum angusta ferrugineo-furfuracea, breviter (2–4 mm.) aciculata, sursum horride aciculata, aciculis diverse directis plerumque porrectis. Pedunculus 5 cm. longus, patenter et breviter aciculatus, aciculis longioribus ca. 4 mm. longis, haud retrosis. Inflor-

escentiae axis simpliciter ramifer inermis, tenuiter ferruginosus, ramis valde angulatim flexuosis ca. 35, deorsum flores ternatim sursum singulatim ferentibus, gracilibus, haud carnosis. Flos centralis femineus, laterales staminei, omnes bracteola subcartilaginea communi probabiliter composita, anguste lunata, obscure 3-apiculata vel integra, subtenti. Flores feminei conici vel subcylindrici, gamosepali, gamopetali; calyce cupuliformi 2.5 mm. diam. (si non applanato) 1 mm. alto, margine minute et distanter triapiculato; corolla 3.5 mm. alta, 2.3 mm. lata, apice profunde (tertia parte) tricuspidata, apicibus triangulo-subulatis, sinubus rotundatis; staminodiis vestigialibus minutissimis; ovario corollam excedente, anguste ablongo, breviter tristigmatoso. Flores masculi in parte rami floriferi terminali singuli, bracteolis singulis vel binis brevibus acutis divergentibus subtenti. Flores staminei 10–12 mm. longi, calyce membranaceo gamosepalo cupuliformi acute triapiculato, si applanato asymmetrice triangulo, angulis acutis. Petala 3 distincta cartilaginea basi subovata apice sublutao longe producta. Stamina 9. Pistillodium nullum.

Specimen typicum fructiferum in Herb. Mich. legit *Percy Gentle*, no. 348, in Dist. Corozal, British Honduras, et specimina alia florentia prope San Andres, Corozal, British Honduras, no. 4750, et fructifera, no 528.

D. quasillarius is the "basket tie-tie" or "basket whist" of northern British Honduras.

Desmoncus uaxactunensis sp. nov.

Scandens maturitate 5–15 m. altus, caule vaginis tecto ca. 4–5 cm. crasso, nudato 2–3 cm. crasso. Folia caulem imbricate vaginantia. Vaginae sursum in ochream ca. 30 cm. longam, griseo-cinnamomeam furfuraceo-pubescentem, apice demum in fibros disolutam dense aciculis tenuibus atratis subascendentibus 4–18 mm. longis praeditam productae. Aciculae juventate fur-furaceae demum nitidae rectae ex papillis bulbiformibus orientes. Petioli para libera ca. 9–12 mm. lata 2 cm. longa et rhachis pars inferior colore vaginae similes furfuraceo-pubescentes aciculis quam eis vaginae brevioribus postice subsparsis antice densius positis obtectae Rhachis ca. 2.25 m. longa, foliolis utrinsecus ca. 25, infimis 25 cm. longis 2 cm. latis; mediis ca. 30 cm. longis 4 cm. latis; supremis ca. 35 cm. longis 4 cm. latis, omnibus utrinque concoloribus vel subtus pallidiusculis, proper margines vel glabratis vel evanescenter furfuraceo-pubescentibus, obscure subplicatis, basi angustatis replicatis apice acuminatis, ven media sola prominenti venis aliis longitudinalibusa equaliter evidentis supra cum venulis obliquis transversis subtus absque venulis transversis, supra prope basin aciculos ca. 10 graciles atratos 2 cm. longos vel breviores barbatim ferentibus etiamque 2 vel 3 alios in nervo medio infra mediam folii partem. Foliola irregulariter alternantia abrupte per solum 2 intermedia 18 cm. longa 18 mm. lata exacte foliacea sed retrorsa transeuntia in uncos 9-jugos subrigidos lateraliter compressos et applanatos non foliaceos, infimos 6 cm. longos, 15 cm. secus rhachin separatos, supremos 1–2 cm. longos, 1 cm. separatos. Cirrhus in extremitate solum modo uncis armatus, deorsum sparsissime spinis gracilibus 2 cm. longis armatus vel subinermis. Ramus fertilis infra spathas semicylindricus 10–13 mm. latus 35–40 cm. longus brunneo-lepidotus omnino in vagina occultus. Spatha inferior etiam semicylindrica, ca. 20 mm. lata, 40 cm. longa, facie plana interiore glabra, pallida, dense longitudinaliter venosa, facie concava tenuiter brunneo-lepidota, apice aperto angustata exfimbriata. Spatha superior fusiformis 28 mm. longa 4 cm. crassa furfuraceo-pubescens et dense

spinis atratis varie aggregatis in tuberculos sedentibus valde flexuosis vel rectis armata. Inflorescentia spatham superiorem non excedens. Pedunculi pars libera 5 cm. longa, 5 mm. crassa, lepidoto-furfuracea spinis 3–5 mm. longis tenuissimis ascendentibus tecta. Axis in parte inflorescentiae ramosa inermis, furfuraceus, 20 cm. longus, ramulos 40–50 floriferos simplices 4–12 cm. longos valde acute angulatim flexuosos ferens. Flores ad ramuli basin ternatim aggregati, ferior et centralis fertilis, staminei bini laterales. Fructus maturus ovoideus 15 mm. longus 12.5 mm. diametiens, minute apiculatus.

Specimen typicum in Herb. Univ. Mich. conservatum legit *H. H. Bartlett* in vicinitate oppidi Uaxactun Mayarum antiquorum, Petén, Guatemala, 18 Apr. 1931, no. 12576.

Desmoncus unaxactunensis differs from the closely related *D. chinantlensis* Liebm. most obviously in the much more slender and more sharply zigzagged branches of the fruiting inflorescence. Under a lens the prophyllum subtending the flower groups is seen to have a sharply triangular retrorse tip which is lacking in *D. chinantlensis*. The beard of slender spines on the base of the top of the lamina consists of a larger group of more closely placed spines. Doubtless other distinctions of flowers and fruit would be obvious if more complete material of *D. chinantlensis* were available for comparison.

Desmoncus ferox sp. nov.

Scandens gracilis, 2 cm. crassus, caule vaginis obtecto. Pars vaginae superior (ochrea) 25 cm. longa, apice demum in fibris dissoluta, sordide albida ferrugineo-furfuracea et dense armata, spiculis ca. 12–22 mm. longis, atris, gracilibus, juventate derosum pubescentibus, basi ex tuberculis cylindricis orientibus. Petioli pars libera 2–3 cm. longa Rhachis tenuiter ferrugineo-pubescens supra aciculis interdum 20–28 mm. longis armata subtus subinermis vel spiculis multum brevioribus praedita, ca. 2.5 m. longa, utrinque usque ad cirrhum (ca. 1 m. longum) foliolos ca. 24 ferens. Foliola inferiora ca. 30 cm. longa, 1.5 cm. lata longe attenuata in caudam filiformem 8 cm. longa; intermedia ca. 29 cm. longa 4 cm. lata, apice solum acuminata non filiformi-caudata; superiora ca. 36 cm. longa, 46 mm. lata acuminata sed sub lente bifida vel praemorsa; omnia longitudinaliter subplicata et venosa, utrinque sub lente tenuissime minutissimeque atro-pubescentia et transverse venulosa, subtus inermia, supra prope basin ferociter multiaciculata, aciculis longitudine eis vaginae rhachisque similibus interdum 30 mm. longis, utrinque acicula sola brevi (ca. 8 mm. longa) in vena media infra folioli medium instructa. Foliola in uncos transeuntia solum 2 subopposita, foliacea, 27 cm. longa, 12 mm. lata, basi uncis similiter tumida et reflexa. Uncorum paria 10, rigida, lateraliter compressa, inferiora 9 cm. longa 26 cm. inter se distantia, intermedia 4.5 cm. longa, 7 cm. distantia. Spatha inferior 22 mm. lata, pars clausa plus quam 21 cm. longa, pars aperta 13 cm. longa, sursum ferrugineo-furfuracea et mediocriter aciculata, aciculis de causa compressionis in vagina plerisque appressis sed prope orificium patentibus 7 mm. longis. Ramus fertilis infra spatham superiorem 11 mm. crassus, appresse et breviter aciculatus, ferrugineus. Spatha superior fusiformis, ca. 40 cm. longa, 3 cm. diametiens, cinnamomeo-albida et ferrugineo-furfuracea, apice breviter filiformi-caudata, deorsum appresse et breviter aciculata sursum valde horride patenter aciculata, aciculis

atratis, diverse directis, longioribus 18 mm. longis. Pedunculus ca. 7 cm. longus deorsum inermis sursum aciculatus, aciculis majoribus 13 mm. longis. Axis inflorescentiae pars ramosa ca. 24 cm. longa, inermis, albida et tenuiter ferrugineo-pubescens, ramos ca. 40 inferiores 15 cm. superiores 6 cm. longos simplices florifcros ferens, ramis (siccis) angulatis, valde angulatim flexuosis, deorsum flores sessiles ternatim sursum singulatim ferentibus. Flores feminei centrales inter 2 masculos siti depresso-globosi 3 mm. lati 2.5 mm. alti gamosepali gamopetali. Calyx subrotundus annulatus breviter margine 3-apiculatus symmetricus 3.3 mm. diam. Corolla cyathiformis margine constricta ovarium includens sessile breviter 3-stigmatosum. Staminodia nulla. Flores staminei calyce gamosepalo membranaceo symmetrico 3.5 mm. diametiente fere perfecte triangulo, angulis productis acuminatis, petalis 3 distinctis carnosis deltoideis, 8–10 mm. longis, acuminatis, basi 1.5–3.0 mm. latis, latioribus subcordatis. Stamina 9, sagittata, filamentis 1 mm. longis tenuissimis antheris profunde sagittatis gravidis 2 mm. longis, i.e. corolla occultis. Pistillodium nullum.

Specimen typicum ad oppidum Mayarum antiquorum Tikal lectum, Petén, Guatemala, *H. H. Bartlett* 12584, 12–15 Apr. 1931, in Herb. Mich.: La Libertad, Petén, Guatemala, *C. L. Lundell* 2646 (6 Apr. 1933; florens) et 3421 (27 Maiae 1933, cum fructibus).

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE GEOLOGICAL SOCIETY

518TH MEETING

The 518th meeting was held at the Cosmos Club October 31, 1934, Vice-President GOLDMAN presiding.

Informal communications: L. G. HENBEST showed lantern slides of pseudomorphs of halite from the De Queen limestone member of the Trinity formation, De Queen, Arkansas.

Program: W. T. SCHALLER: *Kramer borate deposits, California.* Discussed by Messrs. GOLDMAN, JOHNSTON, HENDRICKS, R. C. WELLS, GILLULY, HEWETT, and BAILEY.

R. C. WELLS: *The abundance of certain elements, especially radioactive elements, and related geologic problems.* The first attempt to compute the average chemical composition of known terrestrial matter was made by F. W. Clarke in 1889. Chemists have been adding to the compilation ever since. A recent publication by the Russian chemist A. E. Fersman lists the average abundance or scarcity, as the case may be, of 88 elements, and if account is taken of isotopes, there are now 262 species of matter to be considered. More elements occur in ten-thousandths of a percent than in any other rank of abundance. The radioactive elements have been of great aid in determining the abundance of several elements. These elements have pedigrees. Also, as they evolve heat continuously, there must be a definite limit to their quantity in the earth. They appear to be concentrated near the surface and hence it may be inferred that there is a similar limit to the abundance of elements generally associated with the radioactive elements in the earth's crust. Recent work in the Geological Survey has involved

more particularly the elements uranium, thorium, lead, tin, barium, columbium, tantalum, cesium, and rubidium. (*Author's abstract.*) Discussed by Messrs MERTIE and WASHBURNE.

519TH MEETING

The 519th meeting was held at the Cosmos Club November 14, 1934, Vice-President GOLDMAN presiding.

Informal communications: GEORGE TUNELL told of his visit, during the summer, to laboratories engaged in crystallographic work in Oslo, Stockholm, Helsingfors, Leningrad, and Moscow.

D. F. HEWETT described a manganese depositing hot spring at Hot Springs, Arkansas.

Program: W. P. WOODRING: *Geomorphology of the Palos Verdes Hills, California.* Discussed by Messrs. BRADLEY, HESS, ALDEN, and COOKE.

H. T. STEARNS: *The geologic history of Oahu (Hawaiian Islands).*

Oahu consists of two dissected volcanoes known as the Koolau and Waianae Ranges. The sequence of events in the geologic history of Oahu is summarized as follows:

TERTIARY TIME

1. Building of a dome-shaped island about 3,000 feet high by the extrusion of the lower basalt member of the Waianae volcanic series from southeast and northwest rifts with the center of activity at their intersection near the present site of Kolekole Pass. Extrusion of basalt of the Kailua volcanic series from a rift passing through the site of the present Mokulua Islands forming another island at about the same time. 2. Collapse of the Waianae dome and extrusion of the middle basalt member from the Waianae rifts. The cliffs formed by the collapse ponded the middle basalt and forced most of it to flow north and east. Beginning of erosion to the west of these cliffs, starting the valleys of Nanakuli, Lualualei, Waianae, Makaha, Keaau, and Makua. Shift of volcanic activity a mile south of the Kailua rift with the extrusion of the older layers in the Koolau volcanic series probably about this time. 3. Extrusion of the upper lavas of the Waianae volcanic series and continued erosion of the valleys named above. The main bulk of the Koolau series was probably extruded at this time. 4. Extinction of the Waianae Volcano and the beginning of erosion all over it. Continued extravasation of lava from the Koolau Volcano. 5. Overlapping of the Waianae dome by lavas from the Koolau Volcano resulting in the partial filling of its windward valleys and the joining of the two volcanoes to form a single island. Continued erosion of the leeward side of the Waianae dome.

EARLY (?) PLEISTOCENE TIME

6. Cessation of activity of the Koolau Volcano. Continued erosion of the Waianae dome. 7. Long cycle of erosion resulting in the sweeping away by streams of most of the windward side of the Koolau and part of the leeward side of the Waianae domes. High cliffs formed on the end of interstream divides by marine abrasion. Coral reefs started growing about this time if not before. 8. Gradual submergence of Oahu by more than 1,200 feet resulting in the drowning and sedimentation of the valleys and the formation of the Koolau Pali by the partial burial of interstream divides of large amphitheatre-headed valleys. Continued marine abrasion on exposed headlands and growth of coral reefs.

MIDDLE (?) AND LATE PLEISTOCENE TIME

9. A halt of the sea at 55 feet above present sea level known as the Kahuku stand. 10. Recession of the sea probably about 300 feet below present sea level, known as the Kahipa stand. Erosion of the coastal plain deposits. 11. Rise of the sea to 95 feet above present level known as the Kaena stand, extrusion of some of the Honolulu volcanics, vigorous growth of coral reef off shore, and grading of valley floors to this level. 12. Recession of the sea to 70 feet above present level, known as the Laie stand, more eruptions of the Honolulu volcanics, growth of coral reef off shore, and erosion continued. 13. Halt of the sea at the 40-foot (?) level known as the Waialae stand. 14. Recession of the sea to about 60 feet below the present level known as the Waipio stand, additional eruptions of the Honolulu volcanics, dissection of coastal deposits, vigorous wave attack on headlands, and probably inhibition of coral growth. 15. Rise of the sea to about 25 feet above the present level known as the Waimanalo stand, further eruptions of the Honolulu volcanics, drowning of the mouths of valleys, continued erosion of coastal deposits above the 25-foot level, and growth of coral off shore.

LATEST PLEISTOCENE OR RECENT TIME

16. Recession of the sea to the present level. Koko Fissure and Tantalus-Sugar Loaf eruptions, continued erosion, and probably slowing down in rate of growth of coral off shore. (*Author's abstract.*) Discussed by Messrs. STEPHENSON and ALDEN.

520TH MEETING

The 520th meeting was held at the Cosmos Club November 28, 1934, Vice-President SCHALLER presiding.

Informal communications: Miss M. D. FOSTER displayed a map showing the distribution in the United States of the disease known as "mottled teeth." The endemic areas do not coincide with areas of known fluorspar deposits. In Arizona, ground water containing 1 to 2 parts per million of fluoride causes mild cases, and over 2 parts per million severe cases.

Program: Miss A. I. JONAS: *Pre-Devonian structural zones in Scotland and eastern North America.* Discussed by Mr. GILLULY.

G. W. STOSE: *Comparison of Cambrian section in Northwest Scotland with that of the Northern Appalachians.* Discussed by Miss JONAS and Messrs. MERTIE and RUBEY.

T. L. KESLER: *Granitic injection processes in the Columbia quadrangle, South Carolina.*

Older rocks of the eastern "slate belt" have been intruded by a biotite granite. Northward these older rocks were traced almost continuously into North Carolina where detailed study in several localities has proved them to consist mainly of rhyolitic and andesitic tuffs and breccias with interlayered flows and sills. Southwestward from the quadrangle, the belt was traced farther into Saluda County where its original character is well preserved. The "slate belt" has been altered throughout most of the quadrangle, though original bedding may be frequently recognized. Normal strike averages about N. 55 E. except where deflected by granite masses and dips are steeply N. W. except for local reversals considered to be of little structural significance.

The granite has caused recrystallization parallel to bedding in wide areas of the older rocks where bedding may still be recognized. This is

believed to be due to the ascension of magmatic emanations along the convenient steep dip. It was suggested that the general schistose condition of the older rocks may be thus explained with the development of sericite, biotite, chlorite, and hornblende oriented with their long axes parallel to bedding. Recrystallization is wide-spread, and is believed to indicate a general subjacent source of which the isolated granite masses are satellites. In comparative proximity to these masses, the schists have been subjected to litpar-lit injection and replacement by granitic material. Still nearer the granite, an advanced stage of injection is expressed by granitic rocking which the structure of the older rock is preserved through inheritance of parallel platy ribbons of biotite or the linear arrangement of hornblende. Where the process has been carried to an extreme, replacement and recrystallization have obliterated most of the inherited structure, but the resulting granitic rock contains traces of the older rocks. (*Author's abstract.*) Discussed by Miss JONAS and Messrs. JOHNSTON, CARL BROWN, GILLULY, LOUGHLIN, STOSE, and CURRIER.

521ST MEETING

The 521st meeting was held at the Cosmos Club December 12, 1934, Vice-President GOLDMAN presiding. N. H. DARTON presented a deferred presidential address: *Erosion plans and overlaps in the eastern Maryland region.*

42D ANNUAL MEETING

The 42nd annual meeting was held at the Cosmos Club ofter the adjournment of the 521st regular meeting, Vice-President GOLDMAN presiding. The annual report of the Secretaries was read. The Treasurer presented his annual report showing an excess of assets over liabilities of $1443.38 on December 8, 1934. The auditing committee commended the Treasurer on the condition of his books.

The results of balloting for officers for the ensuing year were as follows: *President:* W. T. SCHALLER; *Vice-Presidents:* M. I. GOLDMAN and H. D. MISER; *Treasurer:* C. WYTHE COOKE; *Secretaries:* W. D. JOHNSTON, Jr., and GEORGE TUNELL; *Members at large of the Council:* A. A. BAKER, C. L. GAZIN, R. M. LEGGETTE, S. W. LOHMAN, and J. S. WILLIAMS; *Nominee as Vice-President of the Washington Academy of Sciences representing the Geological Society:* H. G. FERGUSON.

T. B. NOLAN and W. D. JOHNSTON, Jr., *Secretaries.*

BOTANICAL SOCIETY

254TH MEETING

The 254th regular meeting was held in the Assembly Hall of the Cosmos Club, January 2, 1934, President SMITH presiding; attendance 103. DOROTHY BLAISDELL, MARIE CLARK, BOWEN CRANDALL, and ARTHUR C. FOSTER were elected to membership.

Notes and reviews: DAVID GRIFFITHS reviewed *The fantastic clan* by Thornber and Bouker, a naturalist's treatment of the cactus family. H. B. HUMPHREY called attention to a new book, *William Bartram, the interpreter of the American landscape,* by N. Bryllion Fagin.

Program: ANNIE M. HURD KARRER: *Selenium injury to wheat and its inhibition by sulphur.*—A so-called alkali disease of livestock in certain re-

stricted areas of the Northern Great Plains area has been traced to the presence of selenium in the vegetation. The grain and straw of wheat plants grown in soil at Arlington Farm to which only 1 part per million selenium was added as sodium selenate gave no external evidence of having been affected by the selenium, but were extremely toxic to experimental animals. In order to produce visible symptoms of injury to the plants the selenium concentration in the soil had to be increased to between 10 and 20 parts per million.

The characteristic symptom of injury is a snow-white chlorosis of the young leaves. With extreme injury the entire leaf may be white, maintaining its normal turgidity for some time before withering. More often the tip of the leaf remains green, as does the midvein. A striking symptom occurring sporadically in the selenized seedlings of both wheat and corn was a pink coloration on the chlorotic parts of the leaves. When the selenate was added to pots containing older plants the white chlorosis appeared only on leaves emerging subsequent to the addition of selenium, those already formed merely turning yellow if the selenium concentration was high enough to affect them at all.

The toxicity of sodium selenate for wheat grown in sand and water cultures varied inversely with the amount of sulphur, as magnesium and ammonium sulphate, in the nutrient solution. In water cultures selenium concentrations of 1 p.p.m. are fatal after a few weeks in nutrient solutions made up without sulphate whereas 96 p.p.m. were required for this degree of injury in solutions containing 192 p.p.m. sulphur. There was no visible selenium injury in any solution where the proportion of selenium to sulphur was 1:12 or less, whereas chlorosis was marked in all where the ratio was 1:8 or greater. The point of minimum detectable injury was between 1:9 and 1:11 in all the experiments. In soils, selenium injury was always inhibited by the addition of excess sulphur either as calcium, magnesium, potassium, or ammonium sulphate, or as elemental sulphur. The amount required for a given addition of selenate varied with the latter's toxicity in the particular soil. (*Author's abstract.*)

CHARLES THOM: *An endomycete parasitic to man.*—Histoplasmosis was described by Darling as due to an intracellular parasite, *Histoplasma capsulatum*, apparently unicellular and protozoan in character. The organism isolated by DeMonbreun from a case of histoplasmosis grew in ordinary cultures as a mold, which was found to belong in or near the Endomycetaceae. Ascospores were not found, but chlamydospores characteristic in shape and markings were interpreted as morphologically analogous to asci. The parasite thus falls in a broad group which includes such species as *Coccidioides immitis*. The organism as described presents a unique type of chlamydospore, which will insure its recognition when isolated from future cases. (*Author's abstract.*)

VERA K. CHARLES: *Microsporum of the cat causing ringworm in man.*—Published in full in this JOURNAL 24: 222–227. 1934.

255TH MEETING

The 255th regular meeting was held in the Assembly Hall of the Cosmos Club, February 6, 1934, President SMITH presiding; attendance 65.

Program: A. S. HITCHCOCK: *Taxonomy as a fundamental factor in botanical research.*—All comparative scientific research should be based upon definitely known material, and this principle applies emphatically to botanical research. Taxonomy is fundamentally related to botany in the same sense

that arithemetic is fundamental to other branches of mathematics. Much confusion has resulted, often involving much expense and waste effort, because of failure to secure accurate identifications of sources of drugs, fibers, and other economic plants. Discussed by Messrs. SWINGLE and WAITE

AGNES CHASE: *Some seeds caught in the upper air.*—Seeds taken in insect traps released at different altitudes from an airplane were sent to the Department of Agriculture for study. More than half were those of grasses, for the most part *Paspalum urvillei* and *P. dilatatum.* Of 30 collections, made at from 200 to 5,000 ft., all included spikelets of the first species and about half included the latter species as well. One collection each of *P. pubiflorum* and *Hordeum pusillum* were obtained. Discussed by Messrs. NORTON, THONE and DIEHL.

E. B. LAMBERT: *Climatic phases in the ecology of the compost heap.*—Gas samples taken from all parts of mushroom compost heaps indicate an increase of carbon dioxide and decrease of oxygen toward the lower central part of the heap. In flat heaps three feet deep anaerobic conditions are usually found in areas deeper than one foot and more than three feet from the side of the heap. The highest temperatures (160° to 180° F.) are usually confined to a region two to four feet from the sides of the heap and one foot to three feet from the top. The outer layers are cooler because of the lack of insulation from the outside and the lower central region is cooler because the lack of oxygen retards the microbial activity. At ground level, temperatures (100° to 120° F.) are usually lower than in the higher strata, presumably also because of lack of oxygen. A more uniform distribution of oxygen and wider distribution of the high temperature region is induced by placing ventilating tiles at ground level. In all probability conditions such as these influence the suitability of the finished compost for mushroom culture by establishing the trend of the microbial and insect population of the conpost heap. (*Author's abstract.*) Discussed by Mr. WAITE.

256TH MEETING

The 256th regular meeting was held in the Assembly Hall of the Cosmos Club, March 6, 1934, President SMITH presiding; attendance 85. RALPH C. STAEBNER was elected to membership.

Notes and reviews: M. B. WAITE discussed low temperature injury to peach buds and exhibited a branch of *Ligustrum lucidum,* showing characteristic recovery from freezing injury. W. T. SWINGLE discussed an introduction of date palms from Persia into the United States in 1818, some of which still survive in the sea islands of Georgia.

Program: M. L. BOMHARD: *Recent palm discoveries in Louisiana.*—More than 25 species of palms are cultivated successfully in Louisiana, the most extensive plantings being in the southern part of the State, particularly around New Orleans. The hardy species most frequently cultivated include *Washingtonia robusta, W. filifera, Phoenix canariensis, P. dactylifera, Livistona chinensis, Butia capitata* and its relatives (known "to the trade" as types of *Cocos australis*) including some that have edible fruits, *Trachycarpus excelsa, Chamaerops humulis,* and *Sabal palmetto.* Other species which are well adapted to the lower part of the State, but which are not yet so widely planted as those just listed include *Sabal exul, S. blackburniana, S. causiarum, S. texana, Rhapis excelsa, Rhapidophyllum hystrix, Phoenix reclinata, P. sylvestris, Acrocomia totai,* and *Erythea armata.* All of these, with the exception of *Erythea armata* which flowers only in occasional years, regularly flower and fruit annually, at least in the New Orleans vicinity. A

35-year old specimen of *Phoenix rupicola* may be seen outdoors in New Orleans, but it is given protection during cold weather. The coconut palm, *Cocos nucifera*, and the Royal palm, *Roystonea regia*, have not been grown successfully for periods of more than a few years. *Cocos plumosa* (*Arecastrum romanzoffianum*) is no longer cultivated outdoors in New Orleans, but it may be seen in the orange-country fifty miles to the south.

The town of Monroe in Northeastern Louisiana, where the winters are sometimes severe, achieves a striking tropical effect through extensive plantings of one of the hardiest of palms, *Trachycarpus excelsa*. There are a great many more specimens of the true date palm, *Phoenix dactylifera*, growing in the southern part of the state than most persons realize. These trees flower annually and edible fruits are produced, including some excellent seedless forms. (*Author's abstract.*)

Loren G. Polhamus: *Goldenrod and rubber.*—Following Edison's discovery that goldenrod contains rubber the cultivation and propagation of species of goldenrod have been studied. Variations in growth habit have been found and the possibility of selection on vegetative characters has been demonstrated, but no correlation has been found between growth character and rubber content. Studies have shown that variations in soil and climate affect the rubber content. Outstanding species from the standpoint of rubber content are *Solidago leavenworthii, S. edisoniana, S. altissima, S. serotina, S. fistulosa, S. nashii* and *S. sempervirens.* It has been found possible to propagate goldenrod readily by means of the underground stolons, as many as 500 new plants having been obtained from a single plant of *S. leavenworthii* in one year. Stem cuttings have failed to root but it has been found possible to propagate several species freely by layering. (*Author's abstract.*)

J. I. Lauritzen and R. T. Balch: *Influence of environmental factors on inversion of sucrose in harvested cane.*—The results from experiments conducted during the grinding season: 1930–31, 1931–32, and 1932–33 in Louisiana showed very little inversion of sucrose in sugarcane kept wet by sprinkling irrespective of the variety used. There was less loss of sucrose through inversion during rainy than during dry weather. There was an intimate relation between the loss of moisture and inversion of sucrose; the greater the rate of loss of moisture the greater the proportionate rate of inversion. By adding moisture to cane in which inversion was proceeding rapidly as a result of drying during various periods of time, inversion of sucrose was checked. In cane kept wet during storage at temperatures of 45°, 55°, 65°, and 75° F., very little inversion of sucrose occurred and the amount was similar at each of the temperatures. Among the commercial varieties of sugarcane grown in Louisiana Co. 281 showed the greatest resistance to inversion of sucrose; P.O.J. 36M, and C.P. 807 the least, with P.O.J. 213, P.O.J. 234, Co. 290 ranging between these extremes. No chemical or physiological changes took place during storage that were inimical to sugar manufacture. (*Authors' abstract.*)

257TH MEETING

The 257th regular meeting and annual dinner was held in the ballroom of the Kennedy-Warren, April 3, 1934, President Smith presiding; attendance 142.

Program: Oran Raber: *Teaching botany and botanizing around the world on a floating university.*

258TH MEETING

The 258th regular meeting was held in the Assembly Hall of the Cosmos Club, May 1, 1934, President SMITH presiding; attendance 90. H. P. BARSS, F. A. MCCLURE, JOHN MONTEITH, JR., and LOREN G. POLHAMUS were elected to membership.

Notes and reviews: M. B. WAITE discussed the life history of the large red oak trees formerly lining 12th St., S.W., noting particularly evidence of injury from the extraordinary cold weather of 1899, and the slow growth since the advent of paved streets. H. B. HUMPHREY presented a summary of the precipitation in Washington for the period January 1930 to April 1934, emphasizing the deficiency of 17 inches for the period. J. B. S. NORTON discussed the effect of altitude on opening English elm buds. F. WEISS exhibited greenhouse grown Ixias and called attention to the suitability of this plant for outdoor culture.

Program: A. E. LONGLEY: *The chromosomes of maize.*

F. V. COVILLE: *The Death Valley of California after forty years.*

259TH MEETING

The 259th regular meeting was held in the Assembly Hall of the Cosmos Club, October 2, 1934, President SMITH presiding; attendance 73.

Notes and reviews: A. S. HITCHCOCK reviewed Agnes Arber's new book *The Gramineae.* M. B. WAITE discussed the effects of prolonged and excessive rainfall with high humidity during the record-breaking September with especial reference to the curing of tobacco in Maryland. W. T. SWINGLE reviewed the classical work on horticulture and botany of Brazil, edited by M. Pio Correa, *Diccionaire das Plantas Uteis do Brasil et das exoticas Cultivados.*

A. A. BITANCOURT, subdirector, Instituto Biologico, Sao Paulo, Brazil, made a brief address in response to the welcome extended to him by the President on behalf of the Botanical Society. J. A. STEVENSON exhibited some of Mr. Bitancourt's publications on Citrus diseases.

Program: L. H. FLINT: *Sensitivity of dormant lettuce seed to light and temperature.*—In typical cases of seed dormancy internal processes are effective after a longer or shorter period in overcoming the seemingly inanimate state without special agencies. In the case of lettuce seed which appears subject to classification as dormant, however, it has been found that light is a factor promoting germination. The sensitivity of such lettuce seed to light a few hours after soaking in water is so great that a few seconds' exposure to sunlight is sufficient to insure germination in subsequent darkness at 20° C. This sensitivity is thus comparable with that of photographic film.

It has been found that the longer wave-lengths of visible light, ranging in length from about 5200 to about 7000 Å and characterizing yellow, orange and red light, are effective in promoting germination. The shorter wave-lengths of visible light, ranging from about 5200 to about 4000 Å and characterizing green, blue and violet light, have been found to be effective in inhibiting germination. Seeds exposed to red light for a time sufficient to insure subsequent germination in darkness would not germinate in blue light.

The role of temperature in relation to light-sensitivity in dormant lettuce seed was studied by soaking seeds in water at various periods and then exposing each lot to a uniform illumination. All seeds were put in a moist

chamber at 20° C. following this illumination. The results obtained indicated that whereas at 5° C. the sensitivity of the seed to light was maintained for several weeks, at 25° C. the sensitivity was so altered after 24 hours that the standard illumination was without appreciable effect. This relationship may account for some of the beneficial effects ascribed to soaking seed at low temperatures.

The establishment of a definite inhibitory effect of certain wave-lengths of light on germination appears of added significance because of the fact that these same inhibiting rays have been found to be the ones effecting the phototropic response of green plants. The results thus emphasize the viewpoint that green plants turn toward light of specified wave-lengths not because they could thereby utilize more illumination, but rather because the light inhibited growth on the side of the stem directly exposed to the light. (*Author's abstract.*)

E. H. WALKER: *Some problems and methods in the taxonomy of Chinese plants.*

260TH MEETING

The 260th regular meeting was held in the Assembly Hall of the Cosmos Club, November 6, 1934, President SMITH presiding; attendance 72.

Notes and reviews: F. THONE exhibited *Wild flowers* by Homer D. House a work similar to *The Wild Flowers of New York* issued some years ago by the New York State Museum.

L. H. BAILEY was present as a guest and, after being welcomed by the President, addressed the Society informally. He gave a synopsis of recent botanical history contemporaneous with his own career, expressing judgment on present botanical work and forecasting the future. He referred to his college days under the tutelage of Asa Gray, his service as professor of horticulture "in spite of which he remained a botanist," his term as Dean of the New York State College of Agriculture. He spoke of the enthusiasm of the older botanists and naturalists for their work. He urged the importance of knowing the habits and range of variation of plants in the field. In discussing evolution, he said that we must get back to nature; as yet we can not apply the discoveries of the laboratory to influencing the course of evolution. In commendation of present-day taxonomy, Dr. Bailey spoke of the attention now given to the proper collection of specimens, and in determining the variation and the range of species; he especially recommended the care and completeness shown in modern taxonomic descriptions.

Program: EARL S. JOHNSTON: *Wave-length effects of light on phototropism.*—Experiments on the evaluation of the wave-length of light in its effect on phototropism were carried out, using an improved plant photometer. Oat seedlings were grown between two lights, one standard, the other of a restricted wave-length range. The intensity of the standard was adjusted until seedlings showed no phototropic bending. At such balance points the intensity ratios of one light to the other were determined. The phototropic sensitivity curve rose from 4100 A to a maximum at 4400 A. It then dropped off to a minimum at about 4575 A and again rose to a secondary maximum in the region 4700 to 4800 A. The fall was quite rapid from this point to 5000 A, from where it tapered off very gradually to the threshold on the long wave-length side at about 5461 A.

C. F. ANDRUS: *Cell and nuclear behavior in Ceratostomella and certain other fungi.*—A discussion of cell multiplication and nuclear behavior in the ascus of the species of *Ceratostomella* and *Endoconidiophora*, with some review of

chromosome number and reduction in other Ascomycetes. Various types of direct and indirect cell cleavage that occur previous to ascus formation in *C. moniliformis* were described. The crosier type of cell division is modified to conform to the detached and unwalled condition of the dividing protoplast. Changes in cell shape accompanying cell division were emphasized. A description of nuclear divisions in the ascus included remarks on chromosome structure and number. The vesiculate nature of the spore-producing region of the ascus and the manner of ascospore formation in *C moniliformis* and *C. fimbriata* seem to distinguish the group from more familiar genera of the Ascomycetae. (*Author's abstract*).

261ST MEETING

The 261st meeting was held in the Assembly Hall of the Cosmos Club, December 4, 1934, President SMITH presiding; attendance 50.

Program: N. R. SMITH: *Present trends in soil bacteriological research.* (Address of retiring President).

34TH ANNUAL MEETING

The 34th Annual Meeting was held immediately following the adjournment of the 261st meeting. The recording secretary reported that the Society closed the year with an active membership of 206 and an honorary membership of 4. The names of 8 members had been placed on the absentee list because of temporary absence from the city. The Society lost two members by death, H. C. SKEELS and KARL KELLERMAN. Twelve new members were elected; three members retired from professional work and were elected to honorary membership under the terms of the By-laws: Miss MARY K. BRYAN, Dr. WM. TAYLOR and Mr. C. O. TOWNSEND.

The following officers were elected to serve for the ensuing year: President, W. W. DIEHL; Vice-President, FREEMAN WEISS; Recording secretary, CHAS. T. SWINGLE; Corresponding secretary, NELLIE A. BROWN; Treasurer, NELLIE W. NANCE; N. R. SMITH was nominated as vice-president for the Botanical Society to the Washington Academy of Sciences.

Freeman Weiss, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

NOTES

The Midwinter Meetings.—Washington science was well represented at the various midwinter meetings, especially those of the American Association for the Advancement of Science and affiliated societies at Pittsburgh. The principal address, at the first formal meeting on Thursday evening, December 27, was delivered by Dr. WILLIAM A. WHITE, superintendent of St. Elizabeth's Hospital, on the subject, *Man, the great integrator.* On Friday afternoon, December 29, an illustrated lecture was presented by W. R. CHAPLINE, chief, range research, U. S. Forest Service, on *Forestry fosters new approach to watershed conservation.* Many scientists from Government departments, research institutions and the several universities in the District of Columbia presented papers before the various section and society meetings.

In the exhibit hall, six Washington institutions had displays illustrating some of their many activities. The American Association for the Advance-

ment of Science itself had an exhibit showing various phases of its work in encouraging the development of science, and also giving information on plans for future meetings. Exhibits sponsored by members of the Smithsonian Institution included a model of a solar heating apparatus, a demonstration of the work of the Laboratory of Radiation and Organisms, and a display of lepidoptera. The exhibit of the Carnegie Institution of Washington was devoted to the recent rapid developments in the fields of genetics and embryology, particularly in the field of chromosome topography and gene mapping. The National Bureau of Standards demonstrated work done on deuterium or *heavy hydrogen*, and also displayed a set of new resistance standards. The U. S. Bureau of Mines set forth work done along five separate lines of research on coal and other minerals. The National Geographic Society's exhibit consisted of models and the stratosphere balloon and apparatus used in their joint exploration flight with the U. S. Army Air Corps last summer.

Of special interest at the Annual Science Exhibition of the American Association for the Advancement of Science was an exhibit of research on deuterium and its compounds by laboratories which have been principal contributors in this field of investigation. In this exhibit covering the fields of physics, chemistry, and biology, 13 laboratories were represented, 6 of these having major sized exhibits.

Other midwinter meetings in which Washington scientists participated included those of the Geological Society of America (New York), the Society of American Bacteriologists (Chicago), the Archaeological Institute (Toronto), the American Astronomical Society (Philadelphia), the Chemical Engineering Symposium on Distillation (Cambridge), and the American Historical Association.

Science Advisory Board.—Broad scientific foundations are being sought by the Government, for its future policies of land use. In this search scientists on the Land Use Committee of the Science Advisory Board are taking an active part.

The Land Use Committee acted as a sort of informal liaison organization, enabling fifteen separate government agencies concerned with different aspects of land use to pool their knowledge and obtain an approach to the problem as a whole.

The Committee employed Dr. Carl O. Sauer of the University of California, to make a comprehensive study of the subject as it is known in this country at present. With Dr. Sauer was associated W. L. G. Joerg of the American Geographical Society.

Outstanding on the agenda of problems recommended for first-order investigation is a refinement of studies of climatological records already in existence, to give more reliable bases for decisions as to the habitability of marginal and submarginal lands. If such lands, still in the public domain or now in process of re-purchase, can be withheld from re-settlement when they do not give reasonable promise of yielding a living, repetition of the tragedies of recent drought, and the older ones of the *grasshopper years* of the last century, can be spared the nation.

Important also is the project for a study of permanent natural means of checking soil erosion. At present, major effort is being bent to the construction of gulley dams, partly because the situation in many localities is desperate enough to require engineering works to help it, partly in order to supply jobs for unemployed men. But in the long run, erosion must be held

in check by the roots of grasses, bushes and trees; and it is one of the objectives of contemplated study to find the right species and develop the right planting methods.

National Resources Board.—The National Resources Board has issued a series of reports, on the relation of public works to land and water resources, on land planning, on water planning, on mineral policy, and on a national mapping plan. Reversal of the traditional method of land development is advocated in the land planning report; it calls for the reabsorption into public domain of much land now badly settled and socially expensive, greater care in the release of lands for future settlement, and social control over private transactions in real estate. The necessity for erosion control is also emphasized. In the mineral resources report, stress is lid on the desirability of *holding back* in the use of such minerals as exist in this country in insufficient quantities for normal needs, and at the same time controlling the exploitation of deposits where present surpluses exist. Studies of tariff readjustments and foreign trade agreements as they affect mineral resources are also recommended. The mapping report calls for a ten-year plan to complete the topographic survey of the United States. Only 26 per cent of the total area of the United States exclusive of Alaska and island possessions has been adequately mapped; the rest is mapped either inadequately or not at all. The working program proposes zones of first, second and third priority, based on the urgency of the need for completion. The National Resources Board functions under the chairmanship of Secretary Ickes; its personnel includes Secretaries Dern, Wallace, Roper and Perkins, Relief Administrator Hopkins, Frederic A. Delano, Charles E. Merriam and Wesley C. Mitchell.

National Bureau of Standards.—A new method for investigating the effects of radium rays and X-rays in deep tissues has been developed at the National Bureau of Standards by L. S. Taylor. It stimulates conditions in the human body with wax blocks, which have been named "phantom bodies," and a mixture of carbon bisulphide, tetrahydronaphthalene and ligroin to serve as the radiation-absorbing fluid. An ionization screen, immersed in the fluid, obtains a measure of the degree of ionization caused by the radiations. With further development the instrument may prove of great value in determining the nature and dosage of radiations to be used in treating deep-seated tumors.

Smithsonian Institution.—Thirty ancient Indian village sites and numerous island graveyards along the lower Columbia river have been explored by Herbert W. Krieger, who returned to Washington in January, after six months in the field. The expedition was undertaken in order to salvage archaeological data and material in the area which will be flooded upon the completion of the Bonneville Dam. The region proves to have been thickly settled. In one area, now arid and unpopulated, Dr. Krieger counted the remains of more than five hundred houses. One island cemetery, he learned, had been burned by early white settlers; here he found evidences of fire intense enough to fuse glass beads.

U. S. National Park Service.—Reports of measurements made of glaciers in national parks this past fall by Park Naturalists indicate continued recession. In each instance glaciers were found to have moved and melted back from ten to fifty feet or more.

Geological Survey.—A contract was awarded the Fairchild Aërial Surveys, Incorporated, for furnishing aërial photographs, to be taken with a single-lens camera, of about 5,800 square miles in South Carolina. The photographs will be used to supplement ground surveys for topographic mapping provided for in the Public Works program of topographic surveys.

The possibilities of langbeinite, a potassium-magnesium sulphate identified in certain drill cores from Federal land and private land in New Mexico, as an important fertilizer material, are receiving considerable industrial attention at this time. As this mineral is slowly soluble, it is believed suitable for direct application with the seed, in lieu of the customary application of potash fertilizer at the side of the seed row, and offers advantages in the reduced amount of fertilizer required and in the longer period that the potash remains available to the plant during the growing season.

News Briefs

The Bureau of Mines has awarded contracts for the drilling of a new gas well on the helium-bearing Cliffside structure, in Potter County, Texas, which is expected to bring in a material increase in the Government's available helium supply.

The U. S. Army Air Corps and the National Geographic Society wil[1] undertake another stratosphere balloon flight this spring, it is announced.

A precision cosmic-ray meter, has been installed at the Cheltenham Magnetic Observatory by Dr. Richard L. Doan, Dr. A. H. Compton's assisttant at the University of Chicago, S. E. Forbush of the Department of Terrestrial Magnetism, and George Hartnell of the U. S. Coast and Geodetic Survey, during the first week in January and is now in operation.

Personal Items

By action of the Trustees of the Carnegie Institution of Washington at their annual meeting in December, Dr. John A. Fleming was made Director of its Department of Terrestrial Magnetism beginning January 1.

Dr. Hugh L. Dryden has been promoted to the position of chief of the division of mechanics and sound of the National Bureau of Standards.

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JOURNAL
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VOL. 25 MARCH 15, 1935 NO. 3

PHYSICS.—*Frontiers of aerodynamics.*[1] HUGH L. DRYDEN, National Bureau of Standards.

Tonight we hold the 1077th meeting of the Philosophical Society, beginning the 65th year of activity. By long-standing custom, a special meeting is set apart for the president's annual address, originally the meeting just preceding the annual meeting, but for many years now it has been deferred until the president is relieved of the cares of office. With few exceptions the presidential address has been devoted to a survey of some specialized branch of science, thus fulfilling the prophecy of Professor Henry in his first presidential address that the society should become "a means of instruction to all its members, the knowledge of each becoming, as it were, the knowledge of the whole."

I wish to continue this tradition by outlining to you the present situation on three frontiers of the science of aerodynamics. The territory of aerodynamics is bordered on the north by the great unknown land of unsolved problems of the science itself, on the east by the occupied territory of other specialized sciences such as meteorology, oceanography, hydrodynamics, heat transfer, etc., and on the west by the domain of the practical arts, the home of the engineering fraternity.

I shall perhaps devote what seems to be an undue amount of space to the northern frontier. In these days as never before, many people find it difficult to understand why any attention should be paid to a territory so cold, so barren, so uninviting, so unpromising, so useless, as that of the unknown fields of pure science. Effort expended in that direction bears no promise of immediate large dividends. Many expeditions return fruitless with their original resources expended, apparently a total loss. Others return with a collection of curiosities of no present market value. A recent critic voices his

[1] Address of the retiring president, delivered before the Philosophical Society of Washington, January 5, 1935. Publication Approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce. Received January 17, 1935.

estimate of the returns of some of these expeditions into the unknown as follows:

"Of that which is comprehensible, a high percentage is useless because it deals with pure research work which leads nowhere, or with research into problems which were settled years ago by successful designers.

"The matter of the report is scientific hokum, the manner is literary hooey."

The same critic is very enthusiastic in his support of activities on the western frontier, in what he terms *ad hoc* research as contrasted with *basic* research. In his own words:

"*Ad hoc* research may be defined as hunting for a needle in a haystack, when you do know that a needle is there, whereas basic research is just turning over haystacks on the off chance that there may be a needle or a pin or something worth picking up."

Unfortunately, when one finds the needle which is known to be present in the haystack, he painfully discovers, by the same process by which he discovered the presence of the needle, that there is a pin in the haystack and the haystack must be overturned again, and when the pin is found, behold, there must be a spike present, and so on ad infinitum. Basic research is rather the turning over of haystacks in a particular manner, painstakingly sifting the hay and listing the needles, pins, spikes, and other objects found in the haystack, so that in time it will not be necessary to turn over all of the haystack because the characteristic locations of needles, pins, spikes, etc. will be known.

One can not by ridicule or lack of appreciation detract from the value of a permanent contribution to the knowledge of humanity, or minimize the importance of the many unsuccessful attempts which are an essential part of the attainment of the goal. It is hoped that this brief review of the frontiers of aerodynamics will illustrate by precept and example how the activities on the northern frontier are essential to the welfare of the neighboring territories.

The Philosophical Society had the privilege of hearing the first reports of one of the early expeditions into the north, in a region whose resources we are beginning to appreciate.

A little more than thirty years ago, at the 581st meeting of the Philosophical Society on February 27, 1904, A. F. Zahm reported more fully than he had done at the 554th meeting about two years earlier the results of his three years' experiments on *Atmospheric friction, with special reference to aëronautics*. At the same meeting C. M. Manley spoke on the *History and present status of aeronautics*, and included a discussion of Langley's aerodrome and the accidents in launching

Hugh L. Dryden

President Philosophical Society of Washington

1934

it the preceding fall. Professor Marvin, then president of the society, was in the chair. Langley and Alexander Graham Bell were present and discussed the papers. I often wish I could have been present at that historic and memorable meeting.

In his paper Zahm stated:

"To complete the theory of the skin-friction board, two steps further remain to be taken. First, the equations of motion for a viscous fluid must be integrated to find the velocity at all points in the disturbed region about a thin material plane. Then the speed of flow must be measured at all points next the plane and at some distance away. The writer expects soon to map the stream-lines and measure the velocity. If, then, the equations can be integrated so as to give the speed as a function of the space coordinates, the computed and observed values can be directly compared. It is hoped that some one may obtain sufficiently general solutions of the equations to be of practical value, particularly for the simpler case in which the plane is indefinitely wide, in which the edge conditions are negligible."

I have never asked Dr. Zahm whether he made the attempt "to map the streamlines and measure the velocity." Probably difficulties were encountered, for only within the last few years have adequate methods of measurement been developed. From the data which will be given presently (Fig. 1) we may estimate that the thickness of the disturbed region could not have exceeded 3 inches and was probably much less at the downstream end of the longest board, which was 16 feet long. Certainly the speed was not less than 80 per cent of the speed of the free stream at points more than 0.1 inch from the surface. The completion of this part of the important program outlined by Dr. Zahm had to await the development of a technique of measuring speed very close to a surface.

The pioneer measurements were made by J. M. Burgers and B. G. van der Hegge Zijnen at Delft in 1924 with the aid of a hot wire anemometer. Measurements of the local speed were made at several hundred points for five speeds of the free air stream. Fortunately, it is possible to utilize the methods of dimensional analysis to devise a method of plotting which gives one a general view of the results. The speed V at any point, whose coordinates are x and y with respect to rectangular axes whose origin is at the front edge of the plate, is a function of the speed V_0 of the air stream, of the density ρ and viscosity μ of the air, and of x and y. By dimensional reasoning we find that

$$\frac{V}{V_0} = \phi\left(\frac{V_0 x \rho}{\mu}, \frac{V_0 y \rho}{\mu}\right)$$

Therefore with $V_0 x\rho/\mu$ and $V_0 y\rho/\mu$ as abscissa and ordinate, respectively, we may plot contours along which V/V_0 is constant and equal to assigned values. The resulting diagram is shown in Fig. 1, the ordinates being magnified 200 times with respect to the abscissae. In more familiar terms, if the speed V_0 is 20 feet per second, the numbers along the abscissae are in tens of inches; each square along the ordinates is one-hundredth of an inch; and the contour lines con-

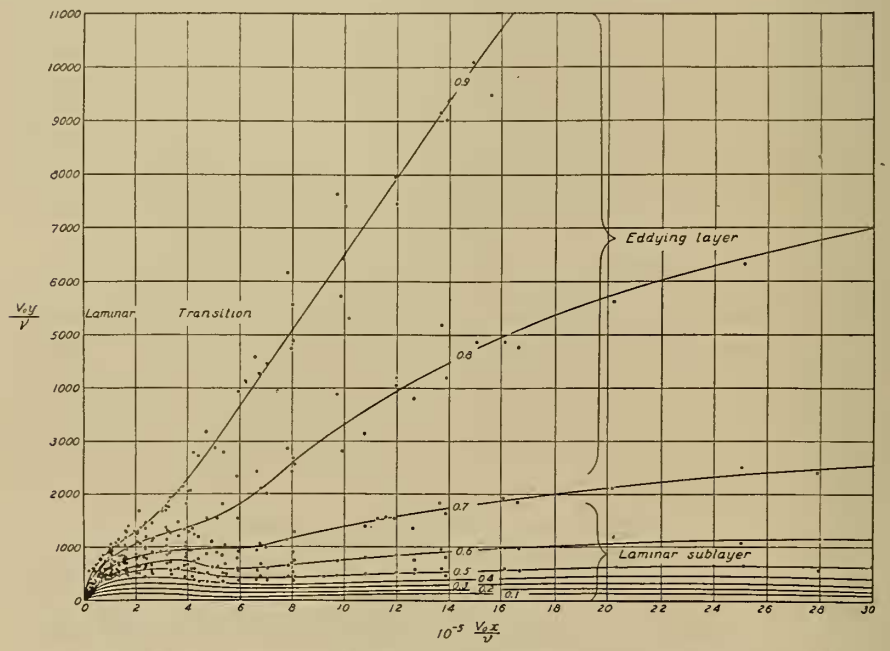


Fig. 1.—Speed distribution near skin-friction plate, van der Hegge Zijnen's measurements. See text for explanation of symbols, except ν which is the kinematic viscosity. $\nu = \mu/\rho$.

nect points whose speeds are 18, 16, 14, 12, 10, 8, 6, 4, and 2 feet per second.

The contour for $V/V_0 = 1$ is not shown, since V approaches V_0 asymptotically. The limited region with an ill-defined outer boundary within which the influence of the plate is felt is the so-called *boundary layer*. It becomes a more real thing when measurements have been made within it and its inner structure has been examined.

Near the upstream edge the contours are approximately parabolic in shape and correspond fairly well to a solution of the Prandtl boundary-layer equations given by Blasius in 1908. The flow in this region is designated *laminar flow*.

From a $V_0 x\rho/\mu$ of about 300,000 to about 500,000, a new phenom-

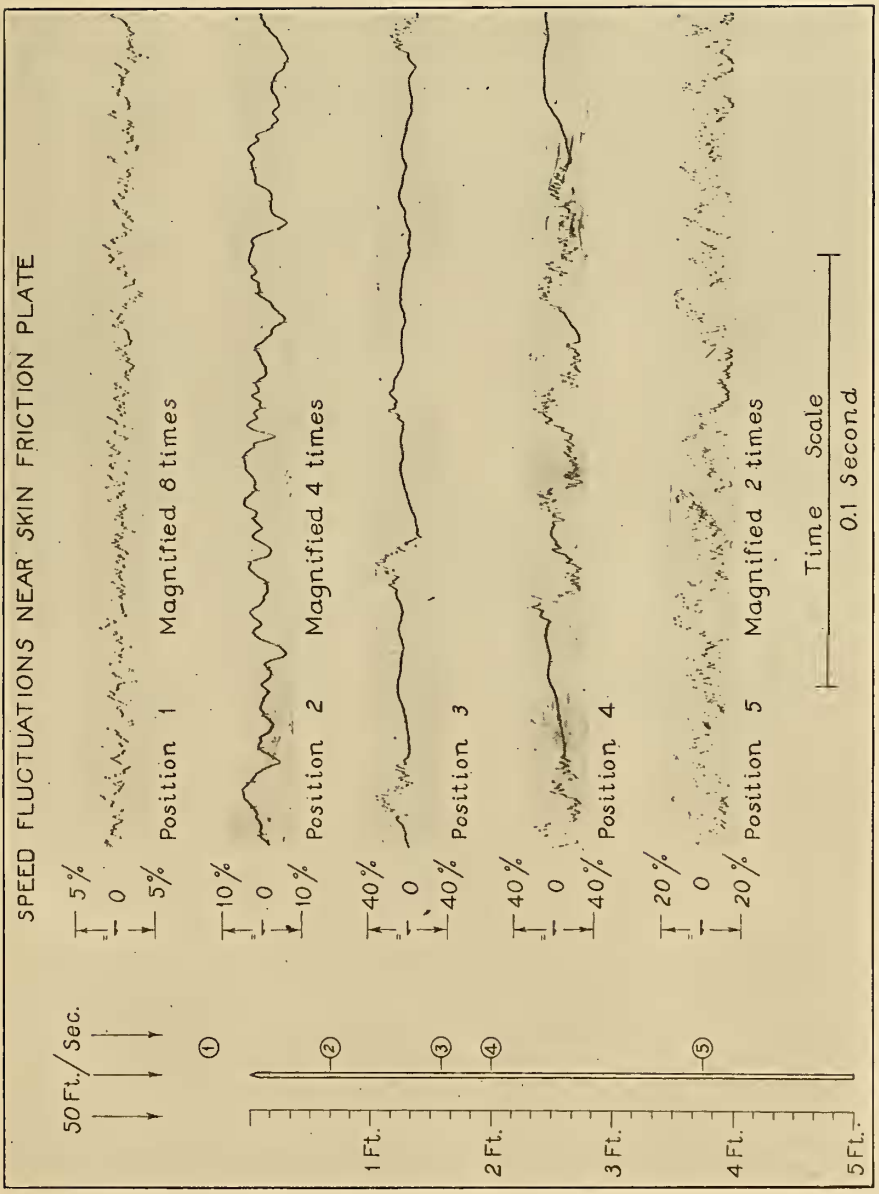


Fig. 2.—Oscillograph records of fluctuations of speed at several points near skin-friction plate.

enon arises, the air close to the surface being accelerated instead of retarded. This region is termed the *transition region.*

There follows a different type of speed distribution. In the region marked *eddying layer,* there is a logarithmic relation between V and y at a given value of x. Near the wall the relations are different, the distribution resembling that in the laminar region. This *laminar sublayer* accounts for two-thirds of the fall in speed but for only a small part of the thickness of the layer.

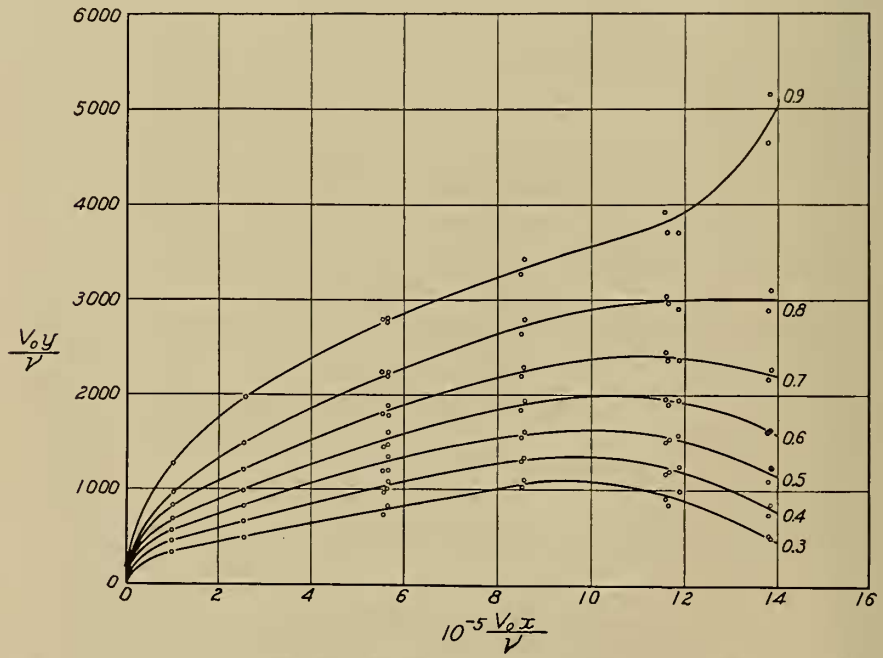


Fig. 3.—Distribution of speed near skin-friction plate, turbulence 0.5 percent. Measurements at National Bureau of Standards.

Apparatus has been developed for measuring the fluctuation of the speed at a given point with time as well as for measuring the mean speed. With this apparatus we may obtain some information as to the nature of the flow of the type indicated in Fig. 2. It may be noted first that small fluctuations are present in the air stream approaching the plate. To this initial turbulence we shall return later. In the laminar region we find fluctuations of amplitude several times that in the approaching stream but much slower. In the eddying region the fluctuations are very rapid. The transition, which appears to be gradual in the measurements of mean speed, is actually a very sudden one. There is an intermittent change from laminar to eddying flow,

occurring at infrequent intervals near the beginning of the transition region and at more and more frequent intervals as the end of the transition region is approached. The phenomenon is identical with that long known to occur in the flow of water in pipes, and frequently exhibited by the aid of streams of dye. The wavering of the color

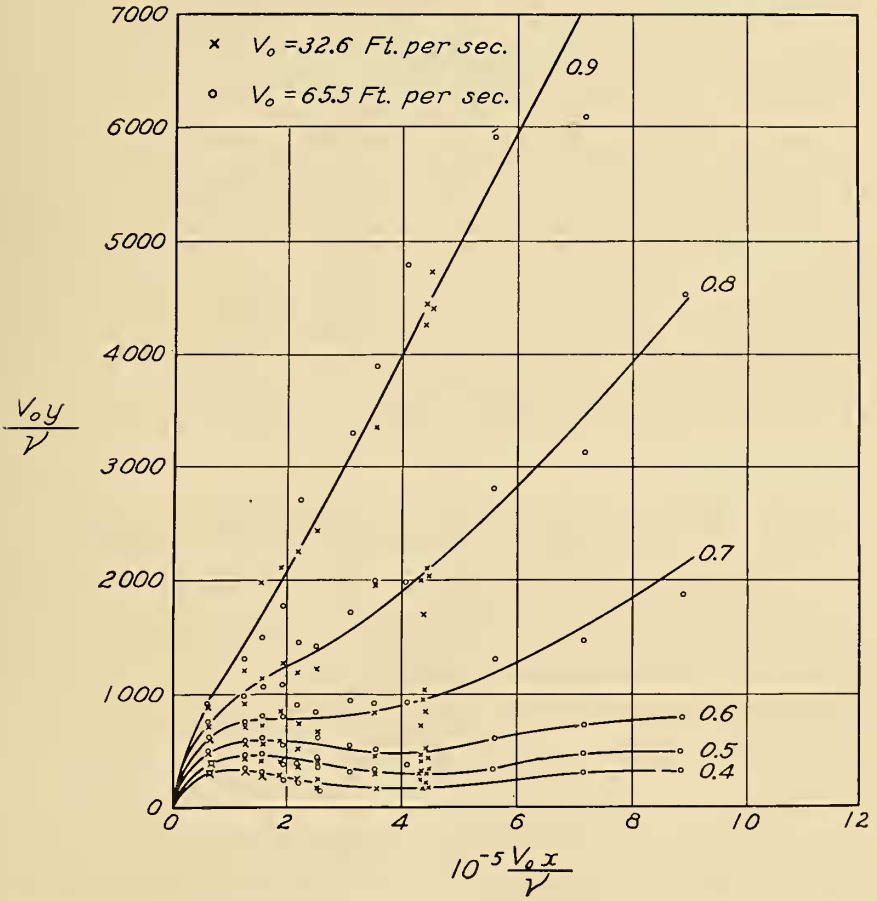


Fig. 4.—Distribution of speed near skin-friction plate, turbulence 3.0 percent. Measurements at National Bureau of Standards.

bands in the laminar flow, the sudden diffusion through the pipe when the flow becomes eddying, the wandering of the point of transition, all are now familiar but not understood.

The true distinction between laminar and eddying flow is not based on the presence or absence of fluctuations. In eddying flow, the fluctuations are of such a nature that there is a net transfer of momentum by the motion of small masses of fluid in addition to the molecular

transfer. In laminar flow, this additional net transfer of momentum does not occur.

It has been found experimentally that the transition from laminar to eddying flow is profoundly affected by the magnitude of the initial *turbulence*, the name given to the small fluctuations of frequencies of the order of 20 to 1000 per second superposed on the desired steady flow. The amplitude of these fluctuations does not ordinarily exceed a few per cent of the average speed, yet a change in this amplitude produces effects of astonishing magnitude in many aerodynamic measurements. For example, Fig. 3 and Fig. 4 show diagrams similar to Fig. 1 plotted from measurements made under the direction of the author in air streams for which the root-mean-square amplitude of the fluctuations was, respectively, 0.5 and 3.0 per cent of the mean speed. The corresponding values of $V_0 x\rho/\mu$ at which transition occurs are 1,100,000 and 100,000, respectively. In other words, at a given speed with a given skin-friction plate the transition occurs at a distance from the leading edge 11 times greater in the first case than in the second. The skin friction and the flow are quite different in the two cases.

There is no suggestion that the laminar flow is stable for small disturbances up to a certain magnitude and that it suddenly becomes eddying everywhere when the disturbance exceeds a certain magnitude. While for a fixed turbulence the transition itself is quite sudden, as we have seen in Fig. 2, there is a progressive and regular functional relationship between the value of $V_0 x\rho/\mu$ at transition and the turbulence of the airstream.

The turbulence of the airstream has been found to be an independent variable of considerable importance in many aerodynamic measurements, chief interest among engineers at the present time being its effect on the maximum lift of airplane wings. Much attention has been given, therefore, to methods of assigning numerical values to the turbulence and to the correlation between the aerodynamic measurements and the numerically assigned values.

It is possible to measure directly the root-mean-square fluctuation of the speed at any point with time by means of a special form of hot-wire anemometer, with a wire of small diameter (0.017 mm), an amplifier, an electrical network to compensate for the lag of the wire, and an alternating current milliammeter. The speed fluctuation is converted into an alternating current whose intensity is measured. The ratio of the root-mean-square fluctuation to the mean speed is defined as the numerical value of the turbulence. The ratio is usually stated as a percentage.

The equipment required for the hot wire measurement is rather cumbersome and requires considerable care and skill on the part of the operator. A more convenient method is to utilize some aerodynamic measurement which is sensitive to turbulence. The measurement most generally used is that of the resistance of a sphere. If one measures the resistance R of a sphere of diameter D in an airstream of speed V_0, the air being of density ρ and viscosity μ, the results may be conveniently expressed as a plot of the resistance coefficient $C_D = \frac{R}{\frac{1}{2}\rho V_0^2 \frac{\pi}{4} D^2}$ against the Reynolds Number $V_0 D\rho/\mu$. At very low Reynolds Numbers C_D is approximately constant and equal to about 0.5. At Reynolds Numbers within a range of values dependent on the turbulence the coefficient decreases rapidly to values in the neighborhood of 0.1. To obtain a definite numerical value it has been proposed to define the Reynolds Number for which C_D is equal to the average of these two values, namely 0.3, as the *critical* Reynolds Number and to use it as a measure of the turbulence.

The measurement of the resistance of a sphere in wind tunnels of varying size is somewhat inconvenient and in any case there is some complication because of the forces on the supports. Therefore there has recently been introduced a pressure-sphere, in which a simpler measurement of differential pressure is utilized. The difference in pressure Δp between an impact hole at the front of the sphere and a hole (or preferably a number of holes) on the downstream side at an azimuth angle of about $157\frac{1}{2}$ degrees from the impact hole is divided by the velocity pressure $q = \frac{1}{2}\rho V_0^2$ to give a pressure coefficient. The critical Reynolds Number is defined as that for which $\Delta p/q = 1.22$. The values obtained are approximately the same as those for which $C_D = 0.3$.

The first comparisons between these methods of measuring turbulence showed extremely good correlation, but as more information became available it became apparent that the critical Reynolds Number of a sphere as defined above depends on the size of the sphere and on other properties of the fluctuations as well as on the root-mean-square amplitude. In some recent work on this problem at the National Bureau of Standards, artificial turbulence was introduced in an airstream by a series of geometrically similar wire screens. For each screen, identified by the mesh distance, different values of the root-mean-square amplitude of the fluctuations were obtained by working at different distances. To avoid variations of mean speed and of turbulence across the stream, the distance had to be greater than 70 times the diameter of the screen wire. The relation between the criti-

cal Reynolds Number of a 5-inch sphere and the hot-wire value of the turbulence for the several screens is shown in Fig. 5. Measurements on a larger sphere show that the correlation is a function of the ratio between the mesh distance and the sphere diameter. It thus

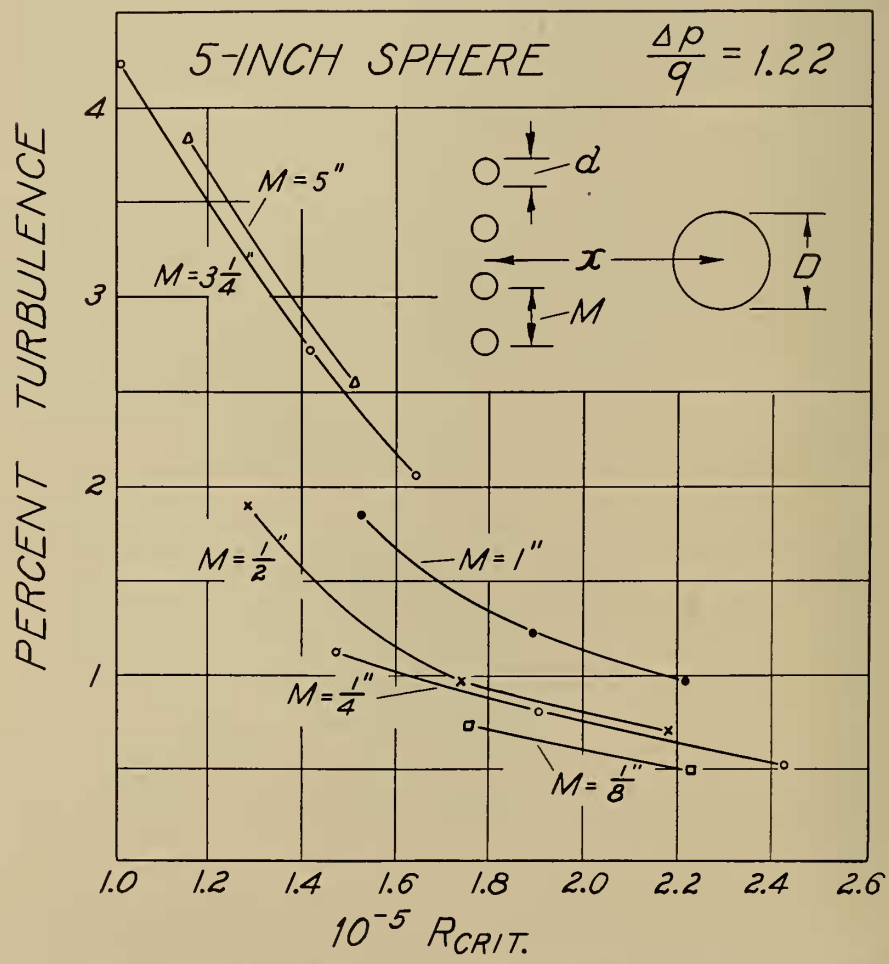


Fig. 5.—Critical Reynolds Number for pressure sphere as a function of root-mean-square fluctuation of speed. Measurements behind geometrically similar wire screens of varying mesh distance M. Square-mesh screens were used.

appears that the wire screens introduce some characteristic pattern (not that of the screen wires which disappears at a distance of 70 wire-diameters) or average size of eddy in the turbulence which affects the flow around a sphere.

Recently Dr. Schubauer at the National Bureau of Standards has introduced a third method of measuring turbulence which promises

to be quite useful. He found that the temperature distribution at some distance downstream from a hot wire of small diameter was a function of the turbulence. The dynamic wake of the small wire disappears at short distances, the wire acting substantially as a line source of heat in a uniform stream. The thermal wake widens at a rate dependent on the turbulence, and the width of the thermal wake between points where the temperature rise is one-half the maximum temperature rise furnishes a suitable measure of the turbulence. The correlation with hot wire measurements is very good and the equipment required is relatively simple, a thermocouple and sensitive galvanometer being the essential elements.

It is perhaps obvious that a completely satisfactory method of measuring turbulence can not be developed until we understand more completely the mechanism of the transition from laminar to eddying flow and the influence of this transition on the flow, pressure distribution, and force acting on bodies immersed in a fluid stream.

We have already noted the effect of the transition on the skin friction. Another basic effect is that on the process of separation. When, for example, air flows around a cylinder, there is a thin well-defined boundary layer only over the forward part. The flow separates from the surface somewhat forward of the median plane, the air near the surface in the region just downstream from the separation zone moving forward in a direction opposite to that of the main stream. Separation occurs when the pressure increases in the downstream direction and the essential features can be derived from the boundary layer equations of Prandtl. The retarding effect of the adverse pressure gradient finally predominates over the frictional transfer of momentum from the faster moving particles. The reversal of flow, on account of the consequent accumulation of fluid, separates the flow from the surface.

If transition to eddying flow in the boundary layer occurs before the separation zone for laminar flow is reached, the process of separation is delayed to a greater azimuthal angle. The eddying flow promotes a more thorough mixing and transfers momentum more readily to the fluid layers near the surface of the cylinder. The behavior of the resistance coefficient or pressure coefficient of a sphere is to be attributed to the effect of the transition on the process of separation and the influence of turbulence on the coefficients is to be attributed to the influence of turbulence on the transition.

The boundary layer at the front of a cylinder differs from that on the skin-friction plate because of the presence of a pressure gradient

in the direction of flow which arises as a result of the increasing speed. This pressure gradient acts to accelerate the flow within the boundary layer and to retard the increase in thickness of the layer. The presence of a small pressure gradient in the wind tunnel airstream is responsible for the supposed discrepancies between experiment and theory in some experiments on skin-friction plates. The theoretical equations show that small pressure gradients have effects much larger than one might suppose.

The existence of an accelerating pressure gradient also affects the transition, delaying it to higher values of $V_0 x\rho/\mu$. The few experiments available indicate that the transition is controlled by the value of $V_0\delta\rho/\mu$ where δ is a suitably defined *thickness* of the boundary layer, for example $\int_0^\infty (1 - V/V_0)dy$. Much more work remains to be done to verify this hypothesis and to study the influence of other factors, such as the curvature of the flow, temperature gradients, etc., on the transition.

The equations of Prandtl describing the flow in a boundary layer are adequate to account for the experimental results so long as the flow is laminar. The unsolved problems of the laminar boundary layer are principally mathematical in character. In the case of eddying flow, even the basic equations are unknown, at least in usable form. Some suppose that the eddying flow represents an unsteady motion which satisfies the fundamental equations of Stokes-Navier for a viscous fluid. Others consider it necessary to introduce additional hypotheses. Notable advances have been made by combining theoretical considerations with empirical results obtained by experiment.

All of these methods begin from the hypothesis of Osborne Reynolds that the flow could be regarded as consisting of a mean flow and a superposed fluctuating motion which could be clearly distinguished. The equations of the mean motion are identical with the equations of Stokes except for certain terms depending on the so-called eddy stresses. The eddy shearing stresses for example are $\rho\overline{u'v'}$, $\rho\overline{u'w'}$, and $\rho\overline{v'w'}$ where the bar denotes mean value, ρ is the density, u', v', w' are the components of the fluctuations at a point. Obviously these stresses are zero unless there is a correlation between the several components.

The eddy shearing stress is analogous to the viscous shearing stress, the eddy fluctuations being analogous to molecular fluctuations. The effect of molecular motions appears in the smoothed equations of motion as the viscosity coefficient. While the viscosity depends only on the temperature, the eddy stresses vary from point to point, being unknown functions of the mean flow. Reynolds general theory

gives no information about the fluctuations themselves, showing only the effect of known fluctuations on the mean motion.

One hypothesis as to the relation between the fluctuations and the mean motion which has been often used is implied in the introduction of the eddy viscosity, a quantity which relates the eddy shearing stresses to the mean motion in the same way that the viscosity relates the viscous shearing stresses to the mean motion. This procedure implies certain relations between the components of the fluctuations at a point, but the eddy viscosity may still vary from point to point. Although a formal simplification results, some assumption must still be made as to the variation of the eddy viscosity throughout the flow.

The analogy between the molecular motions and the eddy motions was pushed somewhat further by Prandtl in the introduction of the mixing length, which plays the same part in the eddy motions as the mean free path in the molecular motions. The isolation of small fluid masses and the mixing length itself actually exist only in a statistical sense. Prandtl's reasoning led to the result that the eddy viscosity was equal to ρl^2 times a function of the mean motion which for a parallel flow reduces to the transverse velocity gradient. The variation of the eddy viscosity from place to place is replaced by a variation of the mixing length l from place to place, which at first sight offers no advantage. But experiment shows that at large Reynolds Numbers the mixing length is practically independent of the speed and simple assumptions as to the spatial distribution give reasonably accurate results.

A further step was taken by von Kármán, who assumed that in the eddying motion the fluctuations at all points were similar, differing only in the linear scale and in the intensity of the fluctuations. This assumption led to an expression for the mixing length in terms of the mean flow and a universal constant. The consequences of the assumption have been worked out rigidly only for the case of parallel flow. The formulae for the skin-friction and for the velocity distribution obtained from Kármán's theory are in remarkably good agreement with experiment.

Until comparatively recently the only experimental information available on the characteristics of eddying flow consisted of measurements of mean values of speeds, pressures, or forces. A beginning has now been made on the experimental study of the fluctuations themselves by several independent methods. The use of the hot-wire anemometer has been studied at Delft, Göttingen, Teddington, California Institute of Technology, and at the National Bureau of Stand-

ards. Fage has applied the ultramicroscope with rotating objective. Townend has developed a technique using small sparks which give *hot-spots* that are rendered visible by the Schlieren method. Lindvall utilized the effect of the wind on a glow discharge between two electrodes. It seems certain that within a few years a considerable amount of information will be available to serve as a guide to the further development of the theory of eddying flow.

The expedition into the unknown begun by Dr. Zahm thirty years ago has thus been followed by others into the same regions, and we feel that we know something more about the territory. New interrelations have been discovered, and we feel that we have the key to the general geographical structure of the country beyond. It is astounding that the study of such a simple problem as the flow of air past a skin-friction plate should lead so far. But as the germ cell contains within itself the possibility of development into a rather intricate structure, so a single problem in aerodynamics contains within itself the possibility of answering many aerodynamic problems.

The account which has been given of studies in this particular section of the northern frontier could be repeated for other sections. One might, for example, describe the further development of another field of investigation to which Dr. Zahm contributed, the behavior of air at speeds near and above the speed of sound. Or one might describe the explorations, which are practically just beginning, on accelerated and unsteady motion, such as is associated, for example, with the pitching of an airplane wing. But we must now turn to the frontier on the east, bordering on the neighboring sciences.

Aerodynamics and hydrodynamics occupy much territory in common and are often regarded as essentially the same. It is true that the language and habits of thought are in large measure identical, but in the details of experimental technique there is sufficient difference that the experimenter in one field is not at home in the other without a season of apprenticeship. The theoretical workers intermingle more freely. Then too there are certain more or less isolated regions in both sciences, for example, the field of compressibility effects in aerodynamics and the fields of free-surface phenomena and of cavitation in hydrodynamics which are distinctive in character.

The indebtedness of the younger science, aerodynamics, to the older is very great. In water, events occur in slower tempo, a given flow-pattern occurring at about one-thirteenth the speed which would be necessary in air. The internal motions of water are readily made visible by small amounts of dye and the eye can in many cases readily

follow the motion. In air, on the other hand, it is necessary to use large volumes of smoke, to take photographs with a high speed motion-picture camera, and to view the pictures at a much reduced speed, if one wishes to observe the motion at reasonably large values of the Reynolds Number. Thus aerodynamics owes not only the underlying theoretical background, but also many of its mental pictures and experimental methods to hydrodynamics.

The benefits have not been altogether one-sided. The circulation theory of lift developed from the stimulus of an aerodynamic problem has found repeated application in hydrodynamic problems relating to hydrofoils, pump and turbine blades, etc. The boundary-layer theory is finding fruitful application in hydrodynamics as well as in aerodynamics. All that has been said about the transition from laminar to eddying flow and the effect of turbulence can be carried over word for word to the flow of water. Even the experimental techniques developed for studying fluctuations in eddying motion in air are beginning to be adapted to similar studies in water.

The sciences of meteorology and oceanography are coming under the influence of aerodynamic ways of thinking. I shall give only one or two illustrations. Atmospheric winds near the Rock of Gibraltar have been found hazardous to aircraft, especially when the wind blows from certain quarters. It occurred to someone to make a model of the rock, put it in a wind tunnel, and explore the flow in detail for several wind directions. The general features were checked by observations in natural winds at the full-scale rock.

About two years ago C. G. Rossby, Professor of Meteorology at the Massachusetts Institute of Technology, published a paper entitled *A generalization of the theory of the mixing length with applications to atmospheric and oceanic turbulence.* The title is self-explanatory. In this paper we find reference to boundary-layers from a 1000 feet to several miles in thickness. In a paper soon to be published by A. M. Kuethe of the Daniel Guggenheim Airship Institute at Akron, we may read of measurements of speed fluctuations within such a boundary-layer.

At the Fourth International Congress of Applied Mechanics, L. Prandtl presented a paper on the application of the laws of turbulent friction to atmospheric phenomena. He treated a number of special problems as well as the problem of the general atmospheric circulation on a rotating earth. Schlichting gave a theory of the stability of the laminar flow in a heated boundary layer and compared the results with measurements by Reichardt at Göttingen. These measurements

were made with a view to their application in meteorological problems.

The theory of heat transfer in forced convection has undergone a veritable revolution by the introduction of the boundary layer as a substitute for the hypothetical *film*. With the introduction of the concepts of laminar and eddying flow, and of transition as dependent on initial turbulence, many apparent contradictions have been explained. As indicated by Pohlhausen and Latzko, we can now proceed several steps beyond the convenient assumption of uniform mass flow of the fluid in studying the theory of forced convection. Thermal boundary layers are recognized as well as dynamic boundary layers. There is a mixing length involved in the transfer of heat as well as in the transfer of momentum and the two may or may not be the same. We introduce an eddy conductivity as well as an eddy viscosity and inquire as to their relationship.

The analogy between heat-transfer and skin-friction has been found very useful. Closer examination is revealing that the analogy has been perhaps pushed too far, ignoring the fact that pressure gradients affect the dynamic but not the thermal boundary layer and that momentum is a vector quantity whereas heat energy is a scalar. This interchange of information is proving beneficial to both sciences, the heat-transfer measurements throwing considerable light on the characteristics of eddying motion.

The study of evaporation and of diffusion has been facilitated by the introduction of the concepts of the laminar sub-layer and of mixing length. The experimental study of the relation between the mixing lengths involved in the transport of momentum, heat, water-vapor, solid particles, etc., promises to throw light on the mechanism of all.

Such are some of the contacts on the eastern frontier. While I do not claim that aerodynamics has always been benefactor and never beneficiary, I do think it is clear that the extension of the knowledge of how air moves near solid bodies immediately makes possible corresponding advances in the neighboring sciences.

We turn now to the western frontier, a region more familiar perhaps than those which we have been considering. Aerodynamics, of course, became of practical importance in the world with the development of aviation, and by far the larger share of aerodynamic research looks to aeronautics for its support. Until very recently, this territory was the only one with which there was efficient inter-communication. However, an adequate discussion of the interchange between aeronautics and aerodynamics, which after all *are* different fields of en-

deavor, would require much more space than can be given here and is perhaps superfluous for the purposes of this paper. The borderland here has long since ceased to be a frontier.

We shall accordingly turn to those regions which are still frontier in character, the first being the borderland between aerodynamics and the practical art of ventilation. The principal aerodynamic problems of ventilation may be briefly stated as (1) the design of fans, (2) the reduction of friction losses in ducts, and (3) the distribution of air from a small number of inlets throughout a large space. The design of fans involves the same fundamental principles as the design of airplane propellers, but a good airplane propeller is not a good fan. Nevertheless, in certain applications, such as in cooling towers used for cooling the water from condensers of steam-turbines, where large quantities of air are required to be delivered against comparatively small pressures, the simplicity and low initial cost of an inexpensive propeller mounted directly on the shaft of an electric motor led to several installations about five years ago. Soon after, aerodynamical principles were applied by one of the manufacturers, leading to a fan with comparatively large hub (one-third to one-half the diameter of of the fan) and with blades whose pitch increases toward the hub, with a very considerable improvement in efficiency. Very recently, Professor Marks and his colleagues at the Harvard Engineering School, have shown that an axial flow fan, with a diffusor and guide vanes, can be constructed to have an efficiency of 80 per cent.

There has also been much interest in the use of fans of this type for forced-draft installations, and for mine ventilation. Multi-stage fan wheels, with alternate rotating and stationary blades, have been proposed. There are, of course, disadvantages as well as advantages. The noise is much greater than for slower speed, multi-blade fans and the power-characteristic curve has some undesirable features. However, the application of aerodynamical knowledge to fan design is only in its infancy.

Information on air friction is immediately applicable in the design of ventilating ducts. However, the exigencies encountered in actual installations lead to many installations where the principal losses are due to obstructions or bends rather than to friction. When air flows around the usual pipe-bend, secondary motions are produced by the action of centrifugal force which destroy the approximately uniform flow. Large-scale turbulence is produced, with large energy losses associated with the dissipation of energy of this turbulence into heat. It has been found that these secondary motions may be largely elimi-

nated by using guide vanes arranged as a series of curved parallel blades which divide the airstream into a number of smaller streams which are separately guided around the bend. I believe these guide vanes were first developed at Göttingen in connection with the return-circuit wind tunnel, a set being installed at each bend. They have since found application not only in wind tunnel design, but in the design of ventilating ducts for large electrical generators. The theory of the action of these vanes is well worked out. The possibilities of their application have not been exhausted.

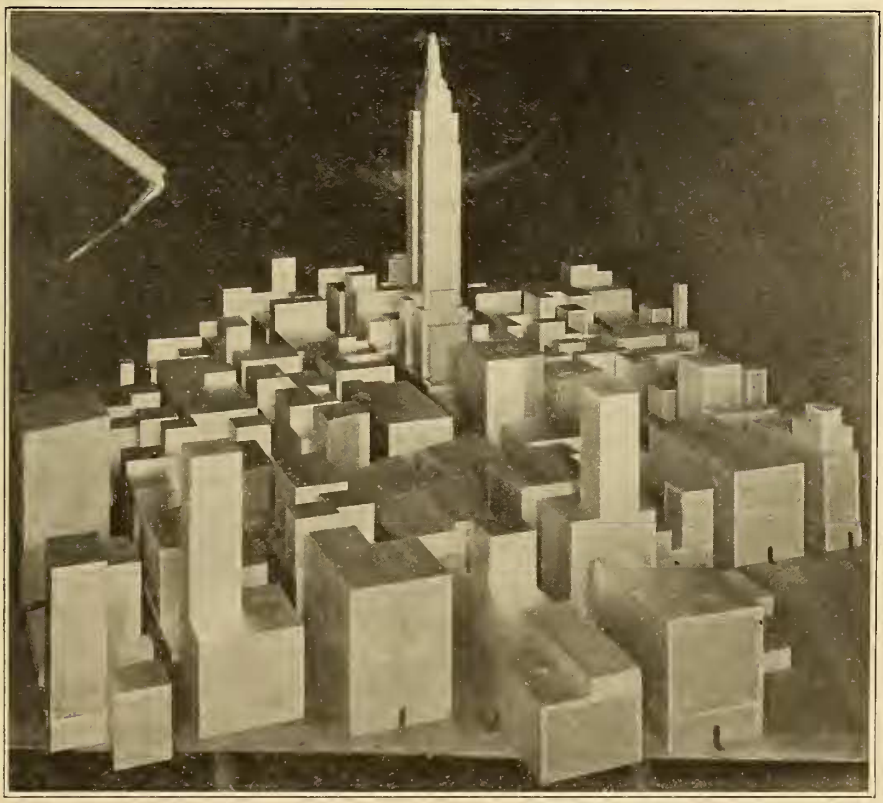
As an illustration of the reduction of losses due to obstructions, the ventilating ducts of the Holland vehicular tunnel may be mentioned. The exhaust duct is formed by the use of a false ceiling suspended from the top of the tunnel. In the original design the ceiling was to be suspended by cylindrical rods. A simple calculation showed that the resulting losses could be greatly minimized by a partial streamlining of the obstructions, accomplished by substituting flat strips edge on to the airstream for the cylinders.

The study of the distribution of air from fresh-air inlets is a virgin field. The investigation of turbulent mixing of jets by Tollmien and others should find immediate application.

Another frontier field is the application of aerodynamics to the design of windmills. Betz in Germany has taken the lead in the study of windmill wheels of few blades suitable for driving electric generators with only moderate gear ratios between the generator and windmill-wheel. His studies have illustrated the possibilities of theoretical computation of the performance and the value of wind-tunnel tests on models as a guide to further development. Two unconventional types, the Savonius rotor and the Flettner rotor, have received some study. In this field, aerodynamics has served to restrain somewhat the expectations of those enthusiasts who feel that because the wind is free, power from the wind should likewise be free. Simple principles show that the structure required to secure reasonable amounts of power from the wind is comparatively large. Initial cost, depreciation, and insurance against damage in high winds must receive careful consideration.

A field to which we have devoted some attention at the National Bureau of Standards is that of determining the wind pressure exerted on structures in wind storms. In the design of tall buildings, radio masts, water towers, chimneys, and similar structures, the allowance to be made for wind pressure is a matter of serious concern, first, in relation to the safety of the structure, and second, in relation to its

cost. To obtain information on wind pressure from observations on a building in a natural wind would require years of measurement and a statistical study of the results. The data so obtained would be limited to buildings of similar shape with a similar exposure. The only practicable procedure is to utilize the long series of observations of the Weather Bureau to forecast the probability of the occurrence of winds



6.—Models of Empire State Building and surrounding structures for wind-tunnel measurements.

of specified speed. To obtain the pressure on the building, the relation between the pressure and the speed must be known. This relation may be determined by experiments on models in wind tunnels or by observations in natural winds. Each method has advantages and disadvantages. The principles of aerodynamics are invaluable in the interpretation of experiments by either method to avoid erroneous conclusions.

The use of both methods is illustrated in the publications of the

Bureau.[2] The wind-tunnel measurements on the model of the Empire State Building were undertaken with the expectation that measurements in natural winds would ultimately be made on the actual building for purposes of comparison. Completion of the project has been delayed by matters beyond our control. To illustrate the extent to which model experiments may be carried, there is shown in Fig. 6 a photograph of the model in the 10-foot wind tunnel with a crude but reasonably accurate representation of the territory for several blocks around. The scale is 1 to 250, the model being 5 feet high.

The results of these experiments and similar experiments abroad are slowly finding their way into building codes and in handbooks on design. The results are even having an influence in the design of houses, barns, and other farm structures as agricultural engineers recommend and insurance companies insist that houses be anchored to foundations, and that roofs be securely fastened to side walls to avoid failure as a result of suction and uplift produced by the wind. Perhaps more surprising is that at least one structure, the airship hangar at Akron, Ohio, has been especially designed to reduce the wind load, *streamlined* if you wish, on the basis of wind-tunnel tests.

As the final frontier region to be discussed, we come to the application of aerodynamical principles to the streamlining of automobiles and trains. When an automobile is driven along a level road, the power developed by the burning of the fuel is used in part to overcome the friction of the gears and bearings and of the tires on the road. The remainder of the power is used to overcome the resistance of the air. At speeds of 35 or 40 miles per hour the rolling resistance and air resistance are approximately equal and at higher speeds the air resistance becomes of the greatest importance.

If the air resistance of an automobile were due solely to air friction, the air resistance would be less than one-tenth that actually present in a typical modern automobile. It is not feasible to reduce the resistance of an actual automobile to this amount for practical reasons, but considerable improvement can be made. Halving the resistance is easily possible.

The possibility of improved fuel economy or higher speed through streamlining has been known for 10 years or more, and several experimental cars have been constructed. None of these cars has been commercially successful, and the so-called streamlining of present-day cars is essentially only a talking point. The accomplishments are trivial in comparison with the reduction that is easily possible. The

[2] Scientific Paper 523, Research Papers 221, 301, 545 and 637.

reason for the delay in introducing truly streamlined cars lies in the repugnance of the public to radical changes in appearance. Attempts are being made by manufacturers to make a gradual transition.

I do not wish to give the impression that there are no engineering problems involved in the change. There are many, but their discussion is out of place here. Their solution is in sight, if not already accomplished by some of the manufacturers.

The railroad groups are also much interested in streamlining. The new streamlined trains, which really owe much of their advantage to the reduction in weight made possible by the use of new materials and new methods of construction, have caught the public fancy. An experiment, which will be of more significance from the standpoint of streamlining alone, is the construction of a streamlined steam locomotive by one of the large manufacturers on the basis of wind-tunnel experiments.

In 1933, the National Bureau of Standards constructed for the Century of Progress Exposition in Chicago a small exhibition wind tunnel, in which were placed two models, one conventional and one streamlined, designed and constructed by W. H. Boyd of the aerodynamics section. Visitors were able to operate the wind tunnel and observe the very great difference in the air resistance of the two models. This exhibit aroused considerable interest and my colleague, R. H. Heald, has investigated not only the head-on air-resistance, but also other aerodynamic characteristics in side-winds. Mr. Heald has also made some studies of methods of representing the ground effect. These studies[3] illustrate the application of the experimental methods of aerodynamics to the streamlining problem.

In the application of aerodynamic methods to aeronautics, ventilation, windmill design, wind-pressure measurements, and streamlining, the contribution of the results obtained from basic research in aerodynamics may not be apparent to the casual observer. A little reflection, however, will show that the discovery, for example, of the very considerable effect of initial turbulence on many aerodynamic measurements must modify both the experimental procedure and the interpretation of the results. Similarly, with other advances in our knowledge of how air flows. Of course, engineers do not stop building airplanes, buildings, or automobiles until the new procedures are developed. The next generation of engineers will take the information which now seems new and use it, forgetting its origin. The present

[3] Research Papers 591, 748, and 749.

generation may continue to feel that basic research is useless, since it does not quickly answer their immediate problems.

And so we end the 1077th meeting. Thirty years from now, at the 1573rd meeting, perhaps someone will again review these frontiers.

BOTANY.—*New species and varieties of* Sedum *from China and Tibet.*[1] N. FRÖDERSTRÖM, Stockholm. (Communicated by E. P. KILLIP.)

The United States National Museum recently submitted to me a number of specimens of *Sedum* from China and Tibet, several of which prove to represent undescribed species and varieties. Most of these novelties were collected by Dr. Joseph F. Rock on his expeditions to the interior of China for the National Geographic Society and the Department of Agriculture.

Sedum aizoon L. var. **obovatifolium** Fröd., var. nov.

Kiangsi Province, Lu Shan; *A. N. Steward* 2602, July 20, 1922. (U. S. Nat. Herb. 1,345,868, type).

Planta robusta, 15–20 cm longa. Folia caulina confertim alterna, obovata, crebre dentata, obtusa, 25–35 mm longa. Inflorescentia densa, multiflora, lata, circ. 1.5×3.5 cm.

Probably but a stout local form of var. *latifolium Max.*, with exceedingly broad leaves. It seems to be nearest to a specimen from the Province of Kwei-chau, near Tschingdshen, about 1200 meters attitude (*Handel-Mzazetti* 10498 June 1917, Herb. Vienna and Fröderström), but the leaves of that specimen are more spathulate-ovate.

Sedum concarpum Fröd., sp. nov.

Yunnan, Likiang, China, alpine meadows, *Rock* 5434, 1922. (type in my herbarium; duplicate in U. S. Nat. Herb., no. 1,512,062).

Planta perennis, glabra, inferne decumbens et radicans, aphylla, in parte media rosulam foliorum et caulem floriferum, erectum, 8–9 cm longum, edens. Specimen nondum florens suberectum, multicaule, apice confertim foliosum. Folia caulium sterilium longe petiolata, fere orbicularia, apice obtusa et mamillata, basi breviter calcarata, 5–25 mm longa. Folia caulis floriferi subpetiolata, obovata, 5–10 mm longa. Inflorescentia (unius speciminis) dense corymbosa, involucrata. Flores anisopentameri, breviter (3–4 mm) pedicellati; bracteae foliis supremis similes. Sepala basi non producta, oblanceolata, prope basin leviter dilatata, apice obtusa vel subacuta, mamillata, aequalia, circ. 5 mm longa. Petala late lanceolata, sutura basali concreta, apice recurva (mitellata), 7–8 mm longa, lutea; stamina interpetala 5.5–6 mm longa, stamina epipetala circ. 2 mm supra basin inserta; antherae subovato-reniformes, circ. 1 mm longae. Squamae nect. late lineari-spathulatae, apice obtusae, circ. 1.1×0.4 mm crassae, in sicco rubrae. Carpella fere erecta, *e basi circ. 3 mm connata*, non gibbosa, satis longistyla, 5–6 mm longa;

[1] Received January 17, 1934.

folliculi 4–6–seminati, placentis rite ligamentosis. Semina subovoidea, breviter funiculata, glabra, circ. 1×0.4 mm.

Species distincta, ad *S. chauveaudi* Hamet et quodammodo ad *S. leucocarpum* Franch. spectans, folia autem petiolata laminis suborbicularibus, sepala aequalia et carpella ad medium connata.

Sedum jupaernse Fröd., sp. nov.

Eastern Tibet, Jupar Range: among rocks on Totuch nira, north of Ba Valley, 13900 ft. *Rock* 14365, July 1926 (U. S. Nat. Herb. 1,509,461, type).

Planta perennis, glabra, monoica?: flores masculos et femineos separatim ferens (an specimen gemellum e duabus plantis dioicis compositum?). Radices plures, percrassae, perpendiculares, usque ad 25 cm longae. Caudex epigaeus pluries divisus, caespitem densum, fere orbicularem formans, basi squamis desiccatis late triangularibus obtusisque cinctus. Caules desiccati valde numerosi, graciles, caules novos fere aequantes. Caules steriles vel nondum florentes erecti vel dispersi, apice confertim foliosi, 1.5–3 cm longi. Caules floriferi numerosi, flabelliformiter dispersi, 2–4 cm longi. Folia omnia lineari-lanceolata, basi non producta, integerrima, apiculata et acuta, 3–5 mm longa. Inflorescentia conferta, pauciflora; bracteae lineares, acutae, 2–2.5 mm longae. Flores omnes pentameri, breviter pedicellati. *Flores masculi:* Sepala semioblonga, subobtusa, 1.5–2 mm longa. Petala subobovata, basi leviter contracta, apice obtusa et submucronata, circ. 2.5 mm longa, in sicco lutea; stamina omnia petalis fere dimidio breviora, 1.5–1.8 mm longa, epipetala 0.5 mm supra basin inserta; antherae late reniformes. Squamae nect. quadratae, apice profunde emarginatae, circ. 0.9×1 mm in sicco luteae. Carpella minuta, late ovata, brevistyla, sterilia, vix 1 mm longa. *Flores feminei:* Sepala ut supra. Petala late ovata, infra medium parum contracta, apice obtusa, 2.5–3 mm longa, in sicco pallide lutea; *staminodia* interpetala circ. 1 mm longa, apice obtusa, epipetala 0.5 mm supra basin inserta, deinde 0.5 mm longa, apice obtusa. Squamae nect. quadratae, apice leviter emarginatae, circ. 0.75×0.80 mm, in sicco luteae. Carpella suberecta, longitudine parum inaequalia, subovoidea, brevistyla, 2.5–3 mm longa; folliculi *1–3–seminati*, placentis rite ligamentosis. Semina solitaria subovoidea, utrinque alata, glabra, 2×0.7 mm; semina alia ovoidea, 1×0.35 mm.

Species vero peculiaris, habitu ad formas chinenses *Sedi quadrifidi Pall.* maxime spectans. Ab omnibus autem differt: flores monoici?, petala lata, stamina floris masculi petalis breviora, flores feminei staminodia ferentes et eorum carpella pauciseminata.

Sedum likiangense Fröd., sp. nov.

Yunnan, Likiang, *Rock* 4991, 1922 (U. S. Nat. Herb. 1,512,574, type).

Planta perennis, glabra, dioica. Radix simplex, gracilis, circ. 10 cm longa. Caudex epigaeus multoties divisus, densissime caespitosus, caespitem fere orbicularem, circ. 10 cm diametro, formans. Squamae basales? Caules desiccati numerosi, graciles, breves. Caules steriles vel nondum florentes stellatim dispersi, apice dense foliosi, 2–3 cm longi. Caules floriferi suberecti vel dispersi, numerosi, 2–3.5 cm longi. Folia omnia lineari-lanceolata, basi breviter calcarata, apiculata et acutissima, 4–7 mm longa. Inflorescentia uniflora vel conferte pauciflora; bracteae lineares, acutae, 3–3.5 mm longae. Flores omnes feminei, tetrameri, breviter pedicellati. Calycis fundus circ.

1 mm altus, sepala semioblongo-triangularia, acuta, 3 mm longa. Petala late oblonga, basi breviter obtuseque producta, apice obtusa, 3–4 mm longa, in sicco rubra; staminum nullum vestigium. Squamae nect. trapezoideae, latiores quam longae, apice planae et emarginatae, 0.6×0.8–1 mm, in sicco rubrae. Carpella suberecta, subovoidea, brevistyla, stylis recurvis, basi circ. 0.5 mm connata, 4–4.5 mm longa; folliculi multiseminati, centis rite ligamentosis. Semina ovoidea, utrinque alata, glabra, circ. 2×0.75 mm.

Habitu valde ad *Sedum juparense* Fröd. spectans, itaque e vicinitate *Sedi quadrifidi Pall.*, a quo tamen differt habitu caespitosissimo, foliis acutissimis et inflorescentia vulgo uniflora.

Sedum megalanthum Fröd., sp. nov.

Type sheets: ♂ S. W. Szechuan, Mt. Konka, Risonquemba, Konkaling, 3960–5335 m; cushion plant, flowers red; *Rock* 16415, June 1928. ♀ Yunnan, eastern slopes of Likiang Snow Range, Yangtze watershed, 14500–15000 ft; *Rock* 9848, 1923–24 (types in my herbarium; duplicates in U. S. Nat. Herb., nos. 1,333,815 and 1,512,070).

Co-sheets: ♂ Yunnan, Yangtze watershed, western slopes of Likiang Snow Range, 12000–13000 ft; flowers carmine red; *Rock* 4346, May–June 1922. ♂ Yunnan, between Likiang, Tungshan, Tuinaoko, and Tsilikiang, dry Yangtze drainage basin, 14500 ft; flowers red; *Rock* 9780, May 1923. ♂ Muli, S. W. Szechuan, Mt. Mitzuga, west of Muli Gomba, 3050–4875 m; rock plant, flowers purplish red; *Rock* 16596, June 1928. ♂ Muli, S. W. Szechuan, Mt. Siga, northeast of Kulu, 4770–4900 m; flowers red; *Rock* 17923, June 1929.

Planta dioica, perennis, 15–20 cm longa. Caudex robustus, erectus, supra terram brevis et latus, paulum divisus, apice squamis siccis, late triangularibus acutisque cinctus. Caules desiccati plures, nigricantes, robusti, 10–15 cm longi. Caules steriles vel nondum florentes erecti, robusti, 15–17 cm longi, apice convertim foliosi, eorum folia media spathulato-ovata, subacuta, 25–30 mm longa. Caules floriferi numerosi vel pauci, erecti vel flabellatim dispersi, satis robusti, 10-20 cm longi. Folia media et superna subpetiolata, laminis ovatis vel suborbicularibus, margine integris vel undulatis vel crenatis, apice apiculato-obtusis, 6–25 mm longa. Inflorescentia dense corymbosa, lata, 10–15–flora, foliis supremis involucrata; bracteae?; pedicelli sparse papillosi, calyce aequales vel longiores. Flores pentameri, magni. *Flores masculi:* Sepala late linearia vel lanceolata, apice obtusa, 2–2.5 mm longa. Petala pseudounguiculata, usque ad basin libera, oblanceolata vel parum latiora, integra, apice obtusa, 7–7.5 mm longa, in sicco lucide rosea. Stamina omnia fere aequilonga, petala parum superantia, epipetala circ. 2.5 mm supra basin inserta; antherae ovatoreniformes, circ. 1 mm longae. Squamae nect. rectangulares, basi parum dilatatae, apice divisae vel profunde emarginatae, circ. 1.5×0.45 mm. Carpella sterilia, brevistyla, lanceolata, 3–3.5 mm longa. *Flores feminei:* Sepala e basi dilatata lineari-lanceolata, apice subobtusa, circ. 3 mm longa. Petala basi parum dilatata, oblanceolata, apice obtusa, 5–5.5 mm longa, in sicco lutescentia; stamina nulla. Squamae nect. quadratae, crassae, apice planae et leviter emarginatae, circ. 1×1 mm. Carpella erecta, brevistyla, late lanceolata, basin versus parum attentuata, 9–10 mm longa, in sicco rubra; folliculi multiseminati, placentis rite ligamentosis. Semina subovoidea, glabra, utrinque alata, apice elongata, 1.5–2 mm longa.

Species habitu *Sedo rotundato* Hemsl. valde similis, differt autem floribus majoribus, petalis pseudounguiculatis, et staminibus alte insertis.

Sedum yunnanense var. **muliense** Fröd., var. nov.

Muli, Mt. Siga, northeast of Kulu, 4300 m; flowers purplish: *Rock* 17915, June 1929 (type in my herbarium; duplicate in U. S. Nat. Herb., no. 1,510,322).

Caules floriferi suberecti, 50–60 cm longi; folia quaternata vel superne ternata, integra vel undulata, obovata vel lanceolata, obtusa, 12–30 mm longa; inflorescentia laxe thyrsoidea, e cymulis paucifloris composita; flores masculi, 5–6-meri, petala subovata, 3 mm longa.

Ad var. *forresti* Hamet spectans, sed habitu, foliorum forma et inflorescentia satis distincta.

Sedum yunnanense Franch. var. **papillocarpum** Fröd. var. nov.

Yunnan, prope Chungtien, circ. 3600 m. *C. Schneider* 3025, Sept. 1914, (U. S. Nat. Herb., no. 776,718, type).

Planta "20–35 cm" longa, quinquecaulis; folia ternata, oblonga, dentata vel sublobata, acuta, 10–30 mm longa. Flores feminei pro specie magni, pentameri; carpella turgida, papillis altis dense instructa, stylis longis recurvisque, 5 mm longa; semina lanceolata, glabra, 1.9×0.45 mm.

Var. *forresti* Hamet proxima, folia autem ternata, carpella magna, dense papillosa, et semina lanceolata.

♀ **Sedum yunnanense** var. **rotundifolium** Fröd., var. nov.

Yunnan, Tungshan, Yangtze drainage basin, east of Likiang; flowers yellowish; *Rock* 10517, 1923 (type in my herbarium; duplicate in U. S. Nat. Herb., no. 1,512,078).

Caulis solitarius erectus, 45 cm longus; folia verisimiliter opposita, denticulata, orbicularia, obtusissima, 20–40 mm longa et lata; inflorescentia paniculata, 13 cm. longa, e cymulis longe pedunculatis, paucifloris composita; flores feminei, 4–5-meri, carpella 3 mm longa stylis recurvis.

Between var. *henryi* Hamet and *Sedum sinicum* Diels (which is probably but a variety of *Sedum yunnanense*), but the leaves are decidedly orbicular and very blunt, and the inflorescence elongate, almost thyrsoid, as in the head species.

♀ **Sedum yunnanense** var. **strictum** Fröd., var. nov.

Muli, Mountains of Kulu, 4150 m; flowers red; *Rock* 18214, Sept. 1929 (type in my herbarium; duplicate in U. S. Nat. Herb. no. 1,510,623).

Caules stricte erecti, usque ad 30 cm longi; folia ovata vel lanceolata, sublobata, apice obtusa, inferiora circ. 10 mm longa, media 15–20 mm. superiora ignota; inflorescentia thyrsoidea, angusta, interrupta, 12 cm longa, e cymulis parvis, confertis composita, flores feminei, 5–6-meri, sepalis petalisque fere aequilongis, 1.2–1.4 mm; squamae nect. longiores quam latae; circ. 0.8×0.6 mm, apice obtusae, in sicco rubrae; carpella basi lata, turgida, stylis longis recurvisque, 3–3.5 mm longa; semina lanceolata, glabra, utrinque breviter alata, circ. 1.2×0.4 mm.

Planta unica defecta, itaque non satis dignoscenda. Ad var. *forresti* Hamet spectans, sed fortasse species distincta ob habitum et structuram floralem.

PALEOBOTANY.—*Fossil plants from the Malacatos Valley in Southern Ecuador.*[1] EDWARD W. BERRY, The Johns Hopkins University.

In my discussion of the Flora of the Loja Basin in Southern Ecuador[2] I mentioned the possible presence of late Tertiary continental deposits around the source of the Rio Catamayo in southern Ecuador near Malacatos (Valladolid) and Vilcabamba south of the Sierra Cajanuma, which separates the headwaters of the Rio Zamora, an Amazon tributary, from those of the Rio Catamayo, a Pacific stream. This suggestion was based on Wolf's early work.[3] Recently through the kindness of Professor Clodoveo Carrión of Loja I have received material from two localities in the Valley of Rio Malacatos as the Catamayo is here called, one 2 km. north and the other 1 km. south of the town of Malacatos.

The material from the former, the exact locality being along the motor road under construction between Loja and Malacatos, consists of but 4 specimens containing well preserved foliage in a fine grained silt or tuff, whitish in color with some yellowish iron stains, and of a sort which is identical with some of the lithologic facies of the plant-bearing material around Loja. Four clearly recognized species are represented. These are the terminal part of a pinnule of the fern *Goniopteris cochabambensis* Berry, a leaf of the polygonaceous genus *Ruprechtia* identical with *Ruprechtia braunii* described by Engelhardt from the Pliocene tuff at Potosí, Bolivia , a leaflet of *Cassia linearifolia* described originally from Loja by Engelhardt, and a leaflet representing a new species of *Pithecolobium* which may be described as follows:

Pithecolobium ecuadorensis n. sp.

Leaflets small, sessile, inequilateral, elongate elliptical in outline, somewhat coriaceous in texture, with entire margins. Length about 2.6 centimeters. Maximum width 10 to 11 millimeters. The tip is somewhat narrowly rounded and except for its asymmetric attitude is practically equilateral. The base is very inequilateral, being ascending on one side and truncately rounded on the other. Midvein stout and curved. Secondaries well marked; there are 6 or 7 on the concave side of the midvein and 7 or 8 on the convex

[1] Received December 10, 1934.

[2] BERRY, EDWARD W. Johns Hopkins University Studies in Geology 10: 79–134, *pl. 1–6.* 1929.

[3] WOLF, T. & RATH, G. VON. Zeit. Deutsch. Geol. Gesell. 28: 392. 1876.

side; except at the base they are regularly spaced, diverging from the midvein at angles in excess of 45 degrees and camptodrome; toward the base they are more crowded, those on the concave side being straighter and diverging at a more acute angle, those on the convex side are curved and diverge at a wider angle. The tertiaries are thin but distinct and comprise 1 or more from the midvein between adjacent secondaries connected with the latter by more or less percurrent nervilles.

This is a very characteristic form. Among previously described fossil species it is very close to *P. oxfordensis* Berry of the lower Eocene Wilcox group of southeastern North America. Among existing forms it is identical with *P. gracilliflorum* Blake of Central America, although I have not compared the fossil with all of the existing species and it may well be that there are upper Amazon species equally similar to the present fossil form, in fact there is a great similarity among the leaflets of all of the existing species.

The genus *Pithecolobium*, or *Pithecellobium* as Martius spelt it, contains over 100 existing tropical species, three-fourths of which are American where they range from the Florida Keys to northern Argentina. In recent years 14 fossil species, all American, have been described. The oldest comprise 4 forms from the lower Eocene of southeastern North America. There is an Oligocene species in the same region; Miocene species in Porto Rico, the Dominican Republic, Trinidad and Colombia; Pliocene species in Bolivia and eastern Peru; and a Pleistocene form in Trinidad.

The second locality is 1 km. south of Malacatos on the west side of an irrigation ditch known as "La toma de agua del Dr. Aguierre." The matrix is a rather dense, bluish, secondarily iron-stained clay, considerably deformed and consequently hackly, but whether due to tectonic forces or slumping can not be stated. This clay has failed to yield any traces of dicotyledonous leaves, but is packed with the pinnules of the fern *Elaphoglossum carrioni* Berry already known in abundance from several localities around Loja, and from its method of occurrence obviously a compound and not a simple fronded type. In addition there are several specimens of *Goniopteris cochabambensis* Berry and *Poacites magnus* Englehardt, the last a large Chusquea-like grass.

The present collection also contains several specimens of the fish *Carrionellus diu-mortuus* Ivor White from the nudo of Cajanuma at the southern end of the Loja Basin.

All of these forms, with the exception of the new species of *Pithecolobium* and the *Ruprechtia*, are common elements in the flora of the Loja Basin, and the deposits of these inter-montane basins in the Ecuadorian Andes are evidently all of approximately the same age.

Recently I described several occurrences of fresh water mollusks and land plants from the Cuenca Basin in Ecuador.[4] These came from near the town of Biblian in the Azogues valley, so that there is now definite evidence of the presence of similar late Tertiary continental deposits of probably fluviatile palustrine and lacustrine character, and possibly eolian as well, largely made up of volcanic ash, over a north and south distance of upwards of 150 miles. It seems very probable that similar fossiliferous deposits of approximately the same age may be expected in the other inter-Andean basins north of the Cuenca Basin.

Malacatos has a present altitude of 5187 feet which is from 1800 to 2100 ft. lower than the plant bearing outcrops in the Loja Basin and about 2800 ft. lower than the similar outcrops in the Cuenca Basin. At the present time the climate at Loja and Cuenca is arid temperate, while that at Malacatos is subtropical. In all cases the fossil plants are mesophytic tropical types and the evidence is clear that there has been a considerable amount of vertical uplift since these deposits were laid down. Whether or not their present altitude is to be ascribed to differential uplift or to deposition at originally different levels can not be stated, although it seems clear that all occurred at the same physiographic stage in the geological history of the region.

[4] BERRY, EDWARD W. This JOURNAL 24: 184–186. 1934.

ZOOLOGY.—*Life history of* Longistriata musculi, *a nematode parasitic in mice.*[1] BENJAMIN SCHWARTZ and JOSEPH E. ALICATA, Bureau of Animal Industry.

This paper contains a brief account and discussion of the life history of a trichostrongyle, *Longistriata musculi*, parasitic in the intestine of the mouse, *Mus musculus*, and readily reared to fertile maturity in white mice. In addition to the conventional account of the life history, the writers have included in this paper information on the course of infection, including a consideration of such problems as the

[1] Received December 10, 1934.

egg production, susceptibility of the host to reinfection following the apparent termination of egg production, and a discussion of the results obtained.

METHODS USED

Live infested mice were shipped to Washington, D. C., from Jeanerette, Louisiana. The feces of these animals were mixed with moist animal charcoal, and the mixture was placed on moist filter paper in covered petri dishes. The infective larvae migrated to the edges of the filter paper which were turned up at right angles to the bottom of the glass dishes. The larvae were readily detected along the edges of the filter paper, usually in clusters, adhering to the paper by their tails and waving the anterior portions of their body. By cutting off portions of the filter paper on which larvae had accumulated and placing the bits of paper in a glass dish containing a small quantity of water, the larvae could be counted readily when comparatively few were present. When large numbers of larvae were obtained in this manner they were counted by the dilution method.

In studying the development of the free-living stages, the writers isolated single eggs with the aid of a capillary pipette, and placed each egg in a drop of very dilute fecal emulsion in a small stender dish having an inside diameter of 20 mm. The dishes were kept in a moist glass chamber containing several layers of wet filter paper. The individual dishes were taken out of the moist chamber as often as necessary and examined microscopically to ascertain the progress in development.

The individual mice were kept and fed in large battery jars, a folded paper hand towel being used as bedding. The animals were fed on oats, and this was supplemented by cabbage twice a week. The feces, bedding and remnants of food particles were removed daily, and the jars were scalded with hot water and then dried. This procedure precluded the possibility of extraneous infection.

In experimental percutaneous infections, the infective larvae in a small quantity of water were placed on various portions of the skin of white mice anesthetized with ether, the mice being kept under anesthesia until the water containing the larvae had evaporated. The larvae were placed on portions of the skin from which the hair had been clipped or shaved. Larvae were introduced into the mouth in a small quantity of water with the aid of a pipette. The lungs, liver, portions of the wall of the alimentary canal and other organs were examined post mortem for larvae with the aid of the Baermann ap-

paratus and in press preparations. The heart's blood and other fluids of the body were removed to glass slides with the aid of capillary pipettes, after being diluted with physiologic saline and examined for larvae. Mature worms were obtained from the lumen of the intestine by slitting the wall of this organ in a glass dish containing physiologic saline and removing the worms from the solution as well as from the lining of the intestine.

The Stoll dilution technique was used in making egg counts. The total fecal output for 24 hours of the mice involved in this investigation in no case exceeded 0.22 gms., and usually weighed about 0.2 gms.; in a few cases the weight was as low as 0.05 gms. In making fecal dilutions for the counts, practically the entire fecal sample was used in nearly all cases. For the purpose of ascertaining the presence of eggs, the salt flotation technique was used.

PREPARASITIC DEVELOPMENT

The segmented eggs eliminated with the feces of infested mice hatched in about 24 hours in laboratory cultures maintained at a temperature of 24°C. The newly hatched larva feeds almost continuously and grows considerably during the feeding period which lasts about 4 days during the summer months. The molting larva is encased in a sheath, the cuticle of the first-stage larva, which apparently is not discarded in water. On solid culture media, consisting of moist animal charcoal to which mouse feces have been added, the sheath is discarded. The exsheathed larva is infective to mice, and is morphologically and physiologically identical with the third-stage larva of other strongyles; as will be shown in connection with its morphology and in the discussion, it should be regarded as corresponding to a third-stage rather than a second-stage larva, on the assumption that the first molt has been suppressed.

EXPERIMENTAL INFECTIONS THROUGH THE MOUTH

Experiment 1. Each of two mice (nos. 1 and 2) was fed 500 infective larvae. Five days after the experimental feeding, the feces of these mice were still free of eggs; 7 days after the experimental feeding a few eggs of *L. musculi* were found in the feces of mouse no. 1 and numerous eggs were found in the feces of mouse no. 2.

Experiment 2. Mouse no. 3 was given 6 feedings of 100 larvae each as follows: May 23, 1 P.M.; May 24, 9 A.M.; May 25, 9 A.M., 4 P.M. and 9 P.M.; May 26, 9 A.M. The mouse was killed on May 26,

11:30 A.M., 70½ hours after the initial feeding and 2½ hours after the last feeding. Post-mortem examination for worms yielded the following results:

Thirty-five larvae showing no increase in size and no progress in development beyond those of the infective larvae, were found in the stomach; in the small intestine there were present 143 larvae, some showing no evidence of growth beyond that of the infective larva, others showing an increase in size, and some showing early signs of the first parasitic molt, in addition to 140 preadult worms corresponding morphologically to fourth-stage larvae of other strongyles; of these worms 63 were males and 77 were females. The large intestine contained 9 living infective larvae. The liver, lungs and heart's blood were examined for larvae with negative results.

Experiment 3. Mouse no. 4 was given 2 feedings of 100 larvae each on May 29, 2:30 P.M., and May 31, 2:30 P.M. This mouse died some time between 4:30 P.M., May 31, and 9 A.M., June 1. Post-mortem examination revealed 30 larvae in the stomach showing no evidence of growth beyond that attained by the infective larvae, 80 worms in the small intestine, of which 49 (18 males and 31 females) were in the preadult stage and 31 were in the infective stage. No larvae were found in the liver and lungs.

Experiment 4. Mouse no. 5 was given 200 infective larvae on June 2. On June 7, 5 days after experimental feeding, this mouse was killed and examined for evidence of infestation with the following results:

The small intestine contained 32 worms of which 22 (15 males and 7 females) were in the preadult stage, but were already in the third or final ecdysis, while the remaining 10 worms (6 males and 4 females) were in the final, or adult, stage, having discarded the sheath of the last molt before the host animal was killed. The females did not as yet contain eggs in the uteri. No worms were found elsewhere in the alimentary canal. The lungs were free of worms.

It is evident from these data that the entry of *Longistriata musculi* larvae through the oral route not only leads to the development of these worms to fertile maturity, as evidenced by the appearance of eggs in the feces of the experimental host animal on the seventh day following the administration of the larvae (experiment 1), but that the entire development takes place in the small intestine, as shown in experiments 2, 3 and 4. All the developmental stages, beginning with those indistinguishable from the infective stage, through the various growth changes in that stage, the first parasitic ecdysis, the preadult

stage, which follows the casting off of the sheath, growth changes during the preadult stage, the second parasitic ecdysis, and adult or final stage which follows the final exsheathing, were found in the small intestine. No evidence was found of a migration of the larvae from the alimentary canal to the liver or lungs. *Longistriata musculi* is, therefore, capable of achieving its full development in the intestine following the ingestion of the infective larvae. The latter reach the stomach first, and in this organ some of them, and perhaps all of them, linger for a while and then pass into the small intestine where sexual maturity is attained following growth and development accompanied by 2 molts. Preadult worms were already present in experimentally infected mice about 48 hours after experimental feeding, and adult worms, not yet fully grown, were found 5 days after experimental feeding. The entire parasitic development, commencing with the ingestion of infective larvae and ending in egg-laying maturity, was completed in 7 days.

EXPERIMENTAL INFECTIONS THROUGH THE SKIN

Mice were exposed to experimental infections through the skin with a view to (1) determining whether the skin is a suitable portal of entry of *Longistriata musculi* larvae into the body of the rodent host; (2) tracing the course of migration of the parasites from the skin to the small intestine; and (3) ascertaining the precise locations in the body where the development of the larvae is resumed after being suspended following the preparasitic molt. The results of experimental percutaneous infections involving 17 mice, examined at various intervals following the exposure of the skin to infective larvae, the intervals ranging from $\frac{1}{2}$ hour to 7 days after infection and corresponding to the periods during which migration, growth and development take place, are summarized in table 1.

An examination of the data presented in table 1 shows among other things (1) that the larvae which were placed on the intact skin actually penetrated this tissue and that some of them were still present in the skin layers 4 hours after having been placed on the surface; (2) that at least one larva was found in the stomach as early as one hour after the exposure of the skin to larvae and that fairly large numbers of larvae were found in the stomach 3, $4\frac{1}{2}$ and 6 hours, respectively, following the placing of the larvae on the skin; (3) that the larvae were found in the stomach before they were seen in the small intestine or that many more were present in the stomach than in the small intestine up to 6 hours following skin infection; (4) that

some larvae reached the small intestine as early as 3 hours after they had been placed on the skin and that 10 hours after skin exposure the number of larvae which were present in the intestine was in excess of those present in the stomach; (5) that 24 hours following exposure of the skin to larvae, the latter were localized exclusively in the small intestine, in which organ they continued their development; (6) that preadult worms were present in the intestine about 48 hours

TABLE 1.—Results of Percutaneous Infections of 17 Mice

Mouse Number	No. of larvae placed on skin	Duration of experiment	Post-mortem results[a]
6	150	1 hour	20 larvae in skin and 1 in stomach; all in infective stage
7	500	2 hours	24 larvae in skin
8	800[c]	1–3 hours	26 larvae in stomach and 5 in intestine; all in infective stage
9	600[b]	½–3½ hours	22 larvae in skin; all in infective stage
10	800[c]	½–4 hours	1 larva in lungs, 2 in esophagus, 15 in stomach, 7 in intestine; all in infective stage
11	1,000	4 hours	4 larvae in skin; all in infective stage
12	1,000	4 hours	Negative
13	1,000	4½ hours	6 larvae in stomach; all in infective stage
14	1,000	6 hours	76 larvae in stomach; all in infective stage
15	150	10 hours	11 larvae in stomach, 27 in intestine; all in infective stage
16	1,000	10 hours	34 larvae in stomach, 94 larvae in intestine; all in infective stage
17	1,000	24 hours	228 infective larvae
18	1,000	24 hours	109 larvae in intestine; stage not noted
19	1,000	48 hours	103 preadult worms in intestine
20	1,000	72 hours	72 preadult worms in intestine
21	200	120 hours	38 worms in intestine; 11 males and 11 females in final stage, and 9 males and 7 females in preadult stage
22	500	7 days	86 fully developed worms (41 males and 45 females in intestine)

[a] Larvae placed on skin as follows: 400 at 11 A.M.; 200 at noon; 200 at 1 P.M. Mouse killed at 2 P.M.
[b] Four consecutive infections of 150 larvae each at intervals of one hour. Mouse killed 30 minutes after final exposure to infections.
[c] Four consecutive infections of 200 larvae each at one-hour intervals. Mouse killed 30 minutes after final exposure to infection.

after skin exposure; (7) and that 5 days after experimental infection the majority of the worms were already in the final (adult) stage, and that 7 days after infection all the worms present in the intestine had attained the adult stage.

Although the data on mouse no. 10 appear to indicate that the path followed by the larvae from the skin to the intestine was the route usually followed by skin-penetrating nematodes, namely from skin to the lungs by way of the circulation and from the lungs to the intestine by upward migration in the bronchioles, bronchi and trachea, and thence back to the alimentary canal, the post-mortem data on the re-

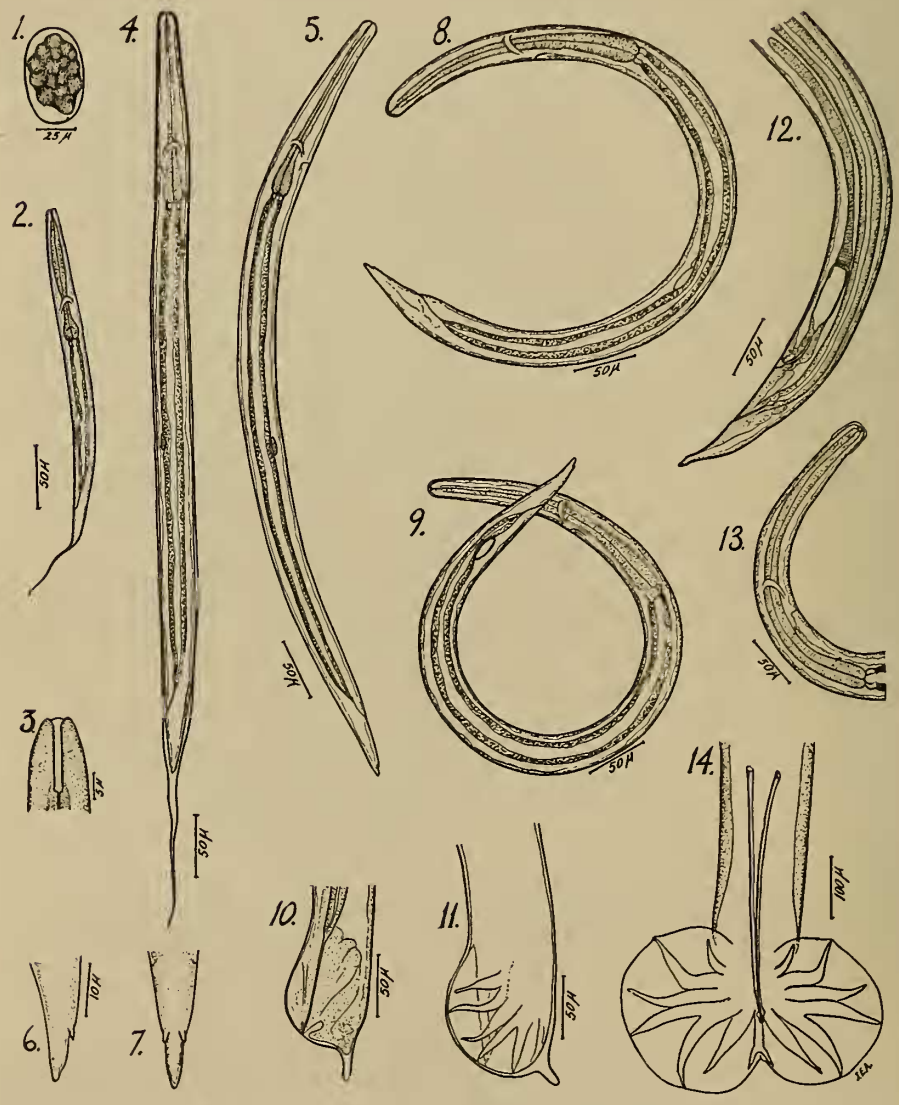


Fig. 1–14.—Stages in the development of *Longistriata musculi*. Fig. 1.—Egg from fresh feces. Fig. 2.—Newly hatched larva. Fig. 3.—Anterior end of preinfective larva. Fig. 4.—Preinfective molting larva. Fig. 5.—Infective larva. Fig. 6.—Tail of infective larva (lateral view). Fig. 7.—Tail of infective larva (ventral view). Fig. 8.—Male larva showing the beginning of the first parasitic molt. Fig. 9.—Female larva showing the beginning of the first parasitic molt. Fig. 10.—Posterior portion of preadult male, 3 days after experimental infection. Fig. 11.—Posterior portion of preadult male in the final molt, 5 days after experimental infection. Fig. 12.—Posterior portion of preadult female. Fig. 13.—Anterior portion of preadult male. Fig. 14.—Bursa of young adult male, 5 days after experimental infection.

maining mice given in table 1 do not support this assumption, despite the evidence that the larvae reached the stomach before they appeared in the intestine in some of the experimental infections. Careful examination of the hearts' blood, the fluid of the peritoneal and thoracic cavities, the lymph glands, lungs, liver, spleen, pancreas, kidneys, and other organs and tissues in which larvae might be present if they were carried in the circulation, yielded consistently negative results in all cases in which such examinations were made, and practically all the mice involved in this investigation were examined with a view to determining the probable path of migration. Aside from this negative helminthological evidence, no lesions suggestive of lung invasion by nematode larvae were noted in any of the mice involved in this investigation. There was a complete absence of petechial and ecchymotic spots in the lungs, lesions usually associated with the invasion of the lungs by nematode larvae.

While the possibility of a direct migration to the alimentary canal through the tissues and cavities of the body must be considered as an alternative to migration through the lungs, the available evidence, especially the failure to find larvae in press preparations of the wall of the stomach and small intestine, lends no support to this possible migratory route. The question of the path followed by the larvae of *Longistriata* from the skin to the alimentary canal must be left open for the time being.

MORPHOLOGICAL ASPECTS OF DEVELOPMENT

The outstanding morphological features in the development of *L. musculi* are shown in the illustrations (figs. 1–14). The brief descriptions which follow help to clarify the illustrations.

Egg.—The egg (fig. 1) has a morphology characteristic of other trichostrongyle eggs; it is 61 to 68μ long by about 38μ wide, elliptical in shape, thin shelled, and segmented when found in fairly fresh feces.

Preinfective larva.—This larva (fig. 2) resembles those of other members of the family Trichostrongylidae. It is slender, cylindrical, tapering slightly anteriorly and more so posteriorly, and is provided with a long filamentous tail. The newly hatched larva is from about 296 to 311μ long by 17μ wide. The mouth opening leads into a cylindrical buccal cavity or pharynx (fig. 3) about 15μ long; the esophagus is characteristically rhabditiform, 91 to 95μ long, its bulb being provided with the usual Y-shaped valve; the intestine, about 120μ long is followed by a short rectum. The nerve ring is about 65 to 79μ, and

the genital primordium 152 to 167μ, respectively, from the anterior extremity. The tail is 60 to 68μ long.

The first preinfective larva grows considerably, attaining a length of 750μ, including the long filamentous tail. At this stage the larva is already ensheathed (fig. 4), the sheath inclosing a short-tailed infective larva.

Infective larva.—Though the infective larva undergoes only one molt, it must be considered as the homologue of the third-stage infective larva of other Trichostrongylidae since it presents morphological features typical of third-stage larvae. In the life cycle of *L. musculi* the molt corresponding to the first molt of other strongyles is evidently suppressed, the molt which takes place being the homologue of the usual second molt since it gives rise to an infective larva.

The infective larva (fig. 5) has the general features of the first-stage larva, differing from the latter principally in the structure of the esophagus and the shape of the tail. It is 610 to 677μ long and 26μ wide. The mouth is closed and leads into a buccal cavity or pharynx about 8μ long, which in turn communicates with a club-shaped esophagus about 163 to 171μ long; the intestine, about 425μ long, is followed by a rectum about 38μ long. The nerve ring, excretory pore and genital primordium are 110μ, 121 to 129μ, and 350 to 587μ, respectively, from the anterior extremity. The tail (figs. 6 and 7) is relatively short and blunt, from 47 to 57μ long, and is provided with two subventral processes located about 10μ from its tip.

Growth of infective larva in host.—In the intestine of the host the third-stage larva increases gradually in length and in width, attaining a size of 750μ by 34μ about 24 hours after experimental infection. Evidence of the first parasitic molt was found in two larvae 725μ long by 26μ wide and 750μ long by 34μ wide, respectively, the smaller worm (fig. 8) being recognizable as a male and the larger worm (fig. 9) as a female, by the respective positions of the genital primordia, that of the female having migrated posteriorly. In the preadult stage the vulva and vagina are seen in the relative position taken up by this genital primordium.

Preadult stage.—The larvae grow considerably during this stage, and show unmistakable sex differentiation. The anterior portion of the larva (fig. 13) shows a small provisional buccal capsule and a cuticular inflation around the head extending to a distance of about 25μ posteriorly. The posterior portion of the male (fig. 10) is distended; the swollen portion forms the bursa and the indistinct folds are the precursors of the bursal rays. In the female (fig. 12) the vulva

and other accessory parts of the reproductive system, as well as the ovary, are well developed about 3 days after experimental infection. At this time the males are 1.38 to slightly over 2 mm. long by 40 to 77μ wide in the swollen posterior portion, and the females are 1.8 to 2.35 mm. long by 50 to 75μ wide. Five days after experimental infection, the preadult worms, already showing evidence of the last ecdysis, are about 3.2 to 3.4 mm. long by 78 to 83μ wide. The rays of the male bursa are fully developed in the worms undergoing the final molt (fig. 11). In a small series of measurements involving only 2 worms of each sex, the males were 3.11 to 3.4 mm. long by 78 to 93μ wide and the females were 3.2 mm. long by 76 to 83μ wide.

Young adult stage.—In young fifth-stage worms, 5 days after experimental infection, the largest females measured 5.1 mm., whereas the largest males were only 4.1 mm. long. In the male at this stage (fig. 14) the bursa and spicules have the characteristic morphology of those of the fully developed adult worm.

DISCUSSION OF LIFE HISTORY

The life history of *Longistriata musculi* presents several interesting features in its development, namely, (1) a deviation from the usual four molts which characterize the development of nematodes generally; (2) the adaptation of the infective larvae to entrance into the host through the mouth and through the skin, either avenue of infection leading to development of the worms to fertile maturity; (3) the migratory course of the larvae following skin penetration, in which the usual route through the lungs is apparently followed only exceptionally; (4) the speed with which the infective larvae reach the stomach and intestine following percutaneous infection; and (5) the failure of the larvae to undergo any evident extraintestinal development following percutaneous infection.

With regard to the number of molts involved in the life history of *L. musculi*, this case is paralleled by the development of *Nippostrongylus muris* as determined by Yokogawa (7). The latter species molts only once during its free-living existence, and the larva is infective to rats after discarding its sheath. Yokogawa regarded the infective larva of *N. muris* as a second-stage larva and considered the development of the worm in the lungs as involving 2 stages, though only one molt was present. Following the first parasitic molt in the lungs, Yokogawa regarded the exsheathed larvae as fourth-stage larvae, a view which fits their morphological status. As already indicated, the writers disagree with Yokogawa's interpretation of the

morphological status of the infective larvae and with his assumption that the growth in the lungs which culminates in a molt involves two stages, one molt being suppressed and, instead, regard the infective larva of *N. muris* as well as that of *L. musculi* as morphologically and physiologically identical with other third-stage strongyle larvae. The morphological identity is evident from the structure of the esophagus which is club-shaped and lacks a masticatory apparatus, in contrast to the rhabditiform esophagus containing a masticatory apparatus which is characteristic of second-stage as well as first-stage strongyle larvae. Moreover, the mouth of third-stage strongyle larvae is closed, whereas in the first and second stages the mouth is open. In this respect, too, the two species under consideration agree with third-stage rather than with second-stage larvae. In addition to the facts already cited, the time which elapses between the hatching of the larvae and the attainment of the infective stage, 4 days in the case of *L. musculi* and 4 to 5 days in the case of *N. muris*, lends additional support to the view that one molt has been suppressed. Under favorable conditions, strongyle larvae molt about 2 days after hatching and molt again two or three days later, the entire preparasitic development being completed in about 4 to 5 days.

From the viewpoint of their behavior, the exsheathed free-living larvae of *N. muris* and of *L. musculi* show the characteristic habits of third-stage larvae. The exsheathed larvae of both forms migrate upwards in culture dishes and bottles and are capable of infecting susceptible hosts, behavior features not exhibited by any known second-stage strongyle larvae. In the opinion of the writers, the preparasitic development of *N. muris* and *L. musculi*, which culminates in a molt, corresponds to the preparasitic development of other strongyles, the first molt being suppressed; the single ecdysis which takes place corresponds to the second molt of other strongyles. It is perhaps significant that the only two species of strongyles of which the free-living development involves only one molt, so far as known at present, are rather closely related and belong to the family Heligmosomidae. It is possible that the suppression of the first molt may be found to be a common feature in the life history of the members of this family.

Since the various stages in the development of nematodes after hatching are separated by molts, the infective larvae of *Longistriata* and *Nippostrongylus* are actually second-stage larvae having a morphology characteristic of third-stage strongyle larvae. However, in order to avoid the designation "third-stage larva" for a worm which has molted only once, the writers propose the following terms for the

stages in the development of strongyles after hatching: First preinfective larva; second preinfective larva; infective larva; preadult; adult. In the two species under discussion, the first two stages are not separated by a molt and only four stages appear after hatching, namely, (1) preinfective larva, (2) infective larva, (3) preadult, and (4) adult. The proposed designations, which have been used in this paper, have the additional advantage of eliminating the term "fourth-stage larva" for a stage in development which can no longer be regarded as larval, since sex differentiation is not only well established but is readily apparent even on superficial examination.

It is quite evident, in view of the rather ample data available on the post-mortem findings in mice at various intervals following percutaneous infection, that the larvae of *L. musculi* become arrested in the lungs only exceptionally even if they do migrate through the respiratory tract. This, as well as the probability of a more direct course of migration to the alimentary canal, accounts for the exceptionally rapid appearance of the larvae in the stomach and intestine following skin penetration. As is well known, the migratory course of various species of hookworms following percutaneous infection is from the skin to the lungs and results in a considerable delay of the larvae in these organs. The boring of the larvae through the pulmonary capillaries, their migration into and from the alveoli, along the ramifying bronchioles, up the bronchi and the trachea and thence into the esophagus, is evidently time consuming and accounts for the relatively long interval elapsing between the penetration of the larvae into the skin and their arrival in the intestine.

The essential facts in the development of *L. musculi* following the entry of the larvae through the skin are in striking contrast to those observed by Yokogawa and others with reference to the development of *N. muris*. The infective larvae of the latter species develop in the lungs, molt there, and enter the intestine as preadults. In fact the writers (4) have shown that infective larvae of *N. muris* are incapable of surviving in the digestive tract of rats, and if they fail to reach the lungs after being swallowed, they pass into the large intestine where they die and are expelled with the feces. *L. musculi*, on the other hand, undergoes its entire parasitic development in the small intestine regardless of the portal of entry into the body of its host. The ability of the infective larvae of this species to penetrate the skin is not correlated with an extraintestinal developmental phase as it is in the case of *N. muris*. The infective larvae of the latter, as a matter of fact, are not well adapted to utilizing the mouth as a portal of entry into

rats, as shown by Yokogawa (7), Africa (1) and by the writers (5). *Nippostrongylus* is a striking example among strongyles of an almost obligatory skin penetrator, since this avenue of entrance into its hosts leads to the lungs whereas an entry through the mouth results as a rule in only a slight infestation or in a failure of the worms to become established in the host.

COURSE OF INFECTION WITH L. MUSCULI

The course of infection with *L. musculi*, in so far as this can be determined by quantitative studies in the form of counts, made at more or less regular intervals, of the number of worm eggs in definite amounts of the feces of the experimentally infected white mice, was studied in 5 host animals of which 3 were infected percutaneously and 2 through the oral route. Each mouse received an initial dose of 500 larvae, and the 3 mice which were superinfected received a similar second dose. The feces of these mice were examined on the sixth day following experimental infection, with negative results in all cases. Eggs were found by the salt flotation technic on the 7th day and the counts were begun either on that day or the next day.

Figure 15 is a graphic representation of the rise and fall in the egg output of the worms in mice nos. 23, 24 and 25 which were infected through the skin. The graphs show that the peak of egg production in the case of mice nos. 23 and 24 was reached on the 9th day after experimental infection, or 2 days after eggs were first noted in the feces, and that eggs were no longer demonstrable in the feces on the 14th day in case of mouse no. 24 and on the 16th day in the case of mouse no. 23. The two mice were superinfected through the skin 18 days after the first infection.

Mouse no. 23 was kept under observation until it died, 69 days after superinfection. During this period only one egg was discovered in the feces on the 9th day and three eggs on the 15th day after superinfection; these eggs were demonstrated by the salt flotation technique. At necropsy no worms were found in the intestine of this mouse.

Mouse no. 24 began to discharge eggs 7 days after superinfection and was still discharging eggs 41 days after superinfection; two days later this mouse died and post-mortem examination showed 18 gravid females and 13 males in the small intestine.

Mouse no. 25 reached a peak of egg elimination 8 days after experimental infection and showed no eggs in the feces 5 days later. Two days after the mouse became negative it was superinfected

percutaneously. An inspection of the graph shows that the slight egg output from the worms of this mouse, beginning 9 days after superinfection, disappeared after a few days, and that following this no eggs were demonstrable in the feces for 30 days, except once as noted on the graph. This was followed by the reappearance of small numbers of eggs in the feces during a period of 15 days at the end of which, 65 days after superinfection, the mouse died. Post-mortem

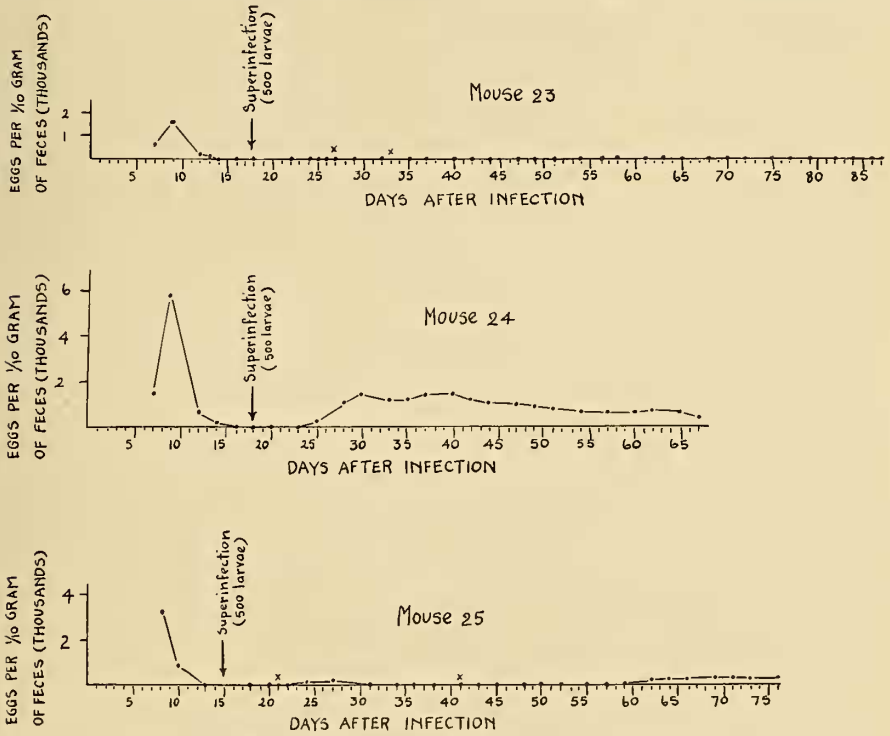


Fig. 15.—Graph of eggs per one-tenth gram of feces of mice nos. 23, 24 and 25, each infected percutaneously with 500 larvae, and superinfected percutaneously with 500 larvae as indicated. x indicates 1 to 3 eggs in total fecal output.

examination showed 22 worms in the intestine, 9 males and 13 gravid females.

From these data it is evident that following percutaneous infection of mice with *L. musculi*, the egg output quickly reached a peak and that this was followed by an equally rapid decline. A superinfection, in so far as available data show, either failed to reestablish egg production, or reestablished egg production at a level lower than that attained during the initial infection. However, the egg output following the second infection, was more stable and persisted for a rela-

tively long time. The egg output of the worms in mouse no. 25, following superinfection, involved a prolonged negative phase between 2 positive phases, due perhaps in part to a delayed development of

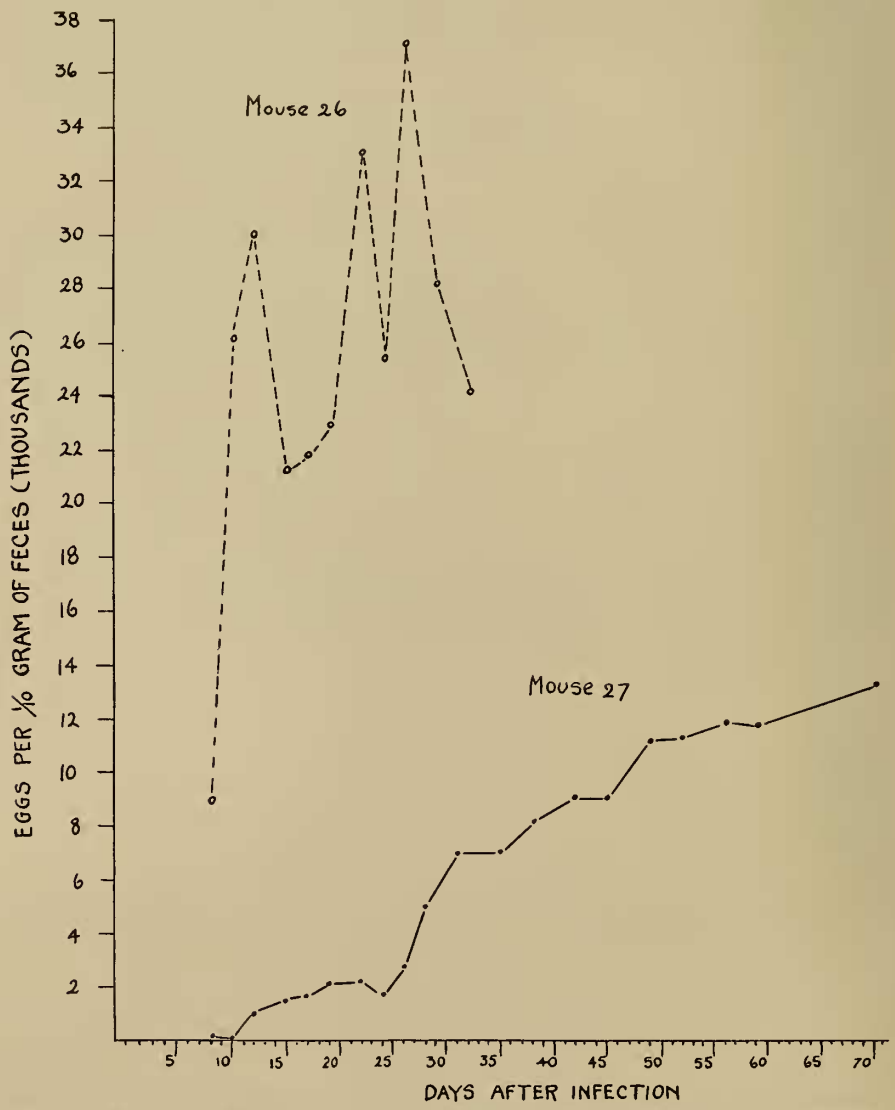


Fig. 16.—Graph of eggs per one-tenth gram of feces of mice nos. 26 and 27, each infected through the mouth with 500 larvae.

some of the worms, similar to the delayed development of *Nippostrongylus muris* following superinfection, as determined by Schwartz, Alicata, and Lucker (5), in 1931, and subsequently confirmed by Chandler (2), Spindler (6), and Graham (3).

The graphs shown in fig. 16 are of the egg output of mice nos. 26 and 27 infected through the mouth. An inspection of these graphs shows not only a tremendously large output of the eggs as compared to that of the mice infected percutaneously, but shows also a prolonged persistence in egg production at high levels. Eggs appeared in the feces of mouse no. 26 seven days after experimental infection and were still being discharged in large numbers 25 days later when the last egg count was made. Two days subsequent to the last egg count this mouse died. Post-mortem examination showed 53 worms in the small intestine, 18 males and 35 gravid females.

In mouse no. 27, infected on the same date as mouse no. 26, eggs appeared 7 days following percutaneous infection. The increase in egg output was more gradual than that in mouse no. 26. Egg production was still on the increase 63 days after experimental infection, the date on which the last count was made. Three days later the mouse died; post-mortem examination showed 103 worms in the intestine, 41 males and 62 gravid females.

It is evident from an inspection of the graphs (figs. 15 and 16) and from the data given in the text, that while eggs were first demonstrable in the feces of the mice 7 days after experimental infection, regardless of the portal of entry of the larvae, the number of eggs discharged by the worms and the duration of egg production are correlated with the portal of entry of the larvae. The percutaneous route resulted in a relatively slight egg output which lasted but a few days, whereas the entry of the larvae through the mouth resulted in a relatively tremendous output of eggs which persisted at high levels as long as the mice survived. The rapid disappearance of eggs from the feces of percutaneously infected mice can not be accounted for on the assumption of slighter infections resulting from the entry of the larvae through the skin, as compared to those resulting from the ingestion of larvae. In a series of experiments involving 5 mice (nos. 28 to 32) infected percutaneously with 300 to 500 larvae, post-mortem worm counts made from 7 to 16 days following infection, yielded 102, 158 and 86 worms, respectively, in the mice given 500 larvae each, and 47 and 55 worms, respectively, in the 2 mice given 300 larvae each, with males and females present in fairly equal numbers in all cases. These figures compare favorably with the number of worms recovered from mice nos. 26 and 27 following infection through the mouth. Assuming, therefore, that the wide discrepancy in the number of eggs produced by the worms following the two avenues of entrance into the host are not due to differences in the percentage of

larvae which actually reached the intestine and developed there to maturity, it is probable that the migration of the larvae from the skin to the intestine, involving a passage through various tissues and cavities, stimulated the defense mechanism of the body. The response to this stimulation is apparently of a sort which interferes with egg production even before the worms die and are eliminated from the intestine. The amazingly low egg output from the worms in mice nos. 24 and 25, despite the presence of 18 and 13 female worms, respectively, in these two animals, as compared to the egg output of the worms in mouse no. 26 which had approximately only twice as many females, or even as compared with the egg output of the worms in mouse no. 27 which harbored 62 females, is certainly suggestive of a host resistance involving among other things inhibition of egg production.

In the case of *N. muris*, the inhibition of development and of egg production has been confirmed by several workers, as already stated, since Schwartz, Alicata and Lucker (5) called attention to this fact. Experimental percutaneous infection of rats with *Nippostrongylus*, as determined by these workers, resulted in most cases in the rapid attainment of a peak in egg production followed, as a rule, by an equally rapid decline. In superinfections, produced following this decline, but few or no eggs were demonstrable in the feces of a large proportion of rats, despite the presence in the intestine of relatively large numbers of worms, including gravid females. The course of infection with *Nippostrongylus* in rats following the invasion by larvae through the skin is similar, as a rule, to the course of infection with *Longistriata* in mice following the same portal of entry. This general similarity in egg production coupled with the same avenue of entrance into the body, suggests that the passage of the larvae of the two species under discussion through the tissues of their respective hosts brings about a defense reaction to the invasion of the parasites which terminates the egg production and, therefore, the multiplicative capacity of the worms, in a few days.

SUMMARY

Under favorable conditions, the eggs of *Longistriata musculi* hatched in about 24 hours after they were eliminated from the host, *Mus musculus*, and the larvae attained their full development in 4 days. Following one preparasitic molt, the larvae were infective to mice.

Although the infective larva has molted only once, its morphology

and behavior are similar to known third-stage trichostrongyle larvae. The view is advanced that the first molt has been suppressed, and the molt which takes place corresponds to the second preparasitic molt of related nematodes. As established by visible molts, it is a second-stage larva, but, as established by morphology and behavior, it is the equivalent of the infective third-stage larva of trichostrongyles in general.

The following designations are proposed in this paper for the stages in the development of strongyles: (1) First preinfective larva; (2) second preinfective larva; (3) infective larva; (4) preadult; and (5) adult. The suppression of one molt during the free-living period reduces the life cycle to 4 stages.

White mice were infected with *Longistriata* through the mouth and through the skin, either portal of entry leading the worms to the small intestine, where they undergo their entire development, accompanied by two molts.

A few hours after percutaneous infection, larvae were found in the stomach and intestine and they became localized in the intestine exclusively 24 hours after having been placed on the skin.

The precise route taken by the larvae from the skin to the intestine has not been determined; evidently, the migratory course usually followed by skin-penetrating nematodes, involving a passage through the lungs, was followed only exceptionally by *L. musculi*, so far as available data show.

Preadult worms, showing unmistakable sex differentiation, were found in the intestine of white mice about 48 hours after experimental infection through the mouth or skin, and final stage worms (adults), not fully grown, were found in these host animals 5 days after entry by either portal.

Regardless of the portal of entry of the larvae, eggs were first noted in the feces of experimentally infected mice 7 days after the administration of larvae.

The period of egg production in 3 white mice infected percutaneously with 500 larvae was limited to approximately two weeks. Superinfection with 500 larvae following the apparent cessation of egg production, yielded practically negative results in one case coupled with absence of worms in the intestine, and resulted in only a small output of eggs in the two remaining mice which harbored worms of both sexes, the egg output being far below the expected output, considering the number of females present.

Following infection with 500 larvae through the mouth, the egg

output from 2 mice reached a far higher level than that attained following percutaneous infection. Moreover, the high level of egg production persisted until the mice died, 32 and 63 days, respectively, following the ingestion of larvae.

It is suggested that the glaring differences in egg production by the worms, the differences correlated with the portal of entry of the larvae into white mice, is probably due to a marked stimulation of the defense mechanism of the host coincident with the migration of the larvae through various tissues following percutaneous infections. This stimulation is either lacking or is not marked following ingestion of larvae.

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PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

259TH MEETING

The 259th meeting of the ACADEMY was a joint meeting with the Medical Society of the District of Columbia, held in the Auditorium of the New National Museum on Wednesday, November 21, 1934. About two hundred and fifty persons were present. President TUCKERMAN introduced Dr. WILLIAM A. WHITE, Superintendent of St. Elizabeths Hospital, who delivered an address on *The frontier of the mind*, which has been published in full in this JOURNAL **25**: 1–15, 1935.

260TH MEETING

The 260th meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club, on Thursday, December 20, 1934. About 60 persons were present. President TUCKERMAN called the meeting to order and announced the nature of a series of programs planned for the future before presenting THOMAS R. HENRY of The Evening Star, who spoke upon, *Introducing science to the public*, and AUSTIN H. CLARK of The Smithsonian Institution, who discussed, *Science and the public*.

261ST MEETING

The 261st meeting of the ACADEMY was held in the Assembly Hall of the Cosmos Club on Thursday, January 17, 1935. About sixty-five persons were present.

Doctor ARTHUR L. DAY, director of the Geophysical Laboratory of the Carnegie Institution, delivered an illustrated address on *Public safety in earthquake regions*.

At the close of the address the President declared a recess, and asked the members to remain for the 37th annual meeting of the ACADEMY.

37TH ANNUAL MEETING

The thirty-seventh annual meeting of the ACADEMY was called to order by President TUCKERMAN at 9:15 P.M., January 17, 1935. Thirty-five members were present. The minutes of the 36th annual meeting were read by the recording secretary and approved by vote of the Academy.

The corresponding secretary reported on the membership and activities of the year 1934 as follows: Twenty-eight persons were elected and qualified as regular members. Twenty-two resignations were accepted; twelve of these were resident and ten non-resident members.

The ACADEMY stood in respect as the Secretary read the list of six members lost by death:

J. M. ALDRICH	ARTHUR SCHUSTER
K. F. KELLERMAN	HOMER C. SKEELS
E. W. NELSON	H. D. GIBBS

On January 1, 1935, the membership consisted of 15 honorary members, 3 patrons, and 536 members, one of whom was a life member. The total membership was 554 members, of whom 398 reside in or near the District of Columbia, 133 in other parts of the continental United States, and 23 in foreign countries. The net loss of membership was 1.

The recording secretary's report summarized five public meetings, two of which were joint meetings, one with the Philosophical Society, the other with the Medical Society.

The treasurer's report detailed the financial operations of the ACADEMY with an itemized list of the assets. A summary of the report showed:

Cash balance, January 1, 1934	$1,365.35
Cash receipts to December 31, 1934	5,132.17
Total cash to be accounted for	6,497.52
Total disbursements	3,970.98
Cash balance, December 31, 1934	2,526.54
Investments, cost at time of purchase, total	21,096.37

F. B. SCHEETZ, chairman, read the report of the auditors verifying the operations of the treasurer's office and the assets of the ACADEMY. On motion of C. J. HUMPHREYS, both reports were accepted and ordered filed.

JOHN A. STEVENSON, senior editor, read the report of the Journal which covered the publication of Volume 24, for the year 1934. Volume 24 consisted of 576 pages, including an eight page index. This compares with 588 pages in 1933, 572 in 1932, 552 in 1931; and 520 in 1930. It contained 78 original papers, as contrasted with 77 in 1933, 79 in 1932 and 80 in 1931. Forty-five papers were by members of the Academy, and 33 were communicated, of which latter number it should be noted six were by authors who became members of the ACADEMY following the time of publication of their papers. The original papers were illustrated by 42 line cuts and 27 half tones. Space in the volume was distributed among the different sciences as follows:

	Pages
2 papers on Mathematics	25.3
1 paper on Physical geography	6.5
5 papers on Physics and geophysics	44.3
9 papers on Chemistry, including pharmacology	37.6
3 papers on Geology, including hydrology and petrology	43.5
1 paper on Biology	1.1
15 papers on Paleontology and paleobotany	67.2
14 papers on Botany	109.6
20 papers on Zoology	90.2
5 papers on Ornithology, malacology, entomology	42.9
3 papers on Ethnology and archeology	12.1

Proceedings of the Academy and affiliated societies occupied 53.4 pages, as follows:

The Academy	4.6
Anthropological Society	1.3
Botanical Society	3.9
Geological Society	18.6
Philosophical Society	15.0

Scientific notes and news, and obituaries occupied the remaining 44.1 pages.

The recording secretary read the report of the tellers showing the election of the following officers for 1935: President, G. W. MCCOY; non-resident vice-presidents, W. M. CLARK, E. D. MERRILL; corresponding secretary, PAUL E. HOWE; recording secretary, CHARLES THOM; treasurer, H. G.

AVERS; managers for the term of three years ending January, 1938, R. S. BASSLER, C. A. BROWNE.

The corresponding secretary read the nominations for resident vice-presidents representing the affiliated societies, as follows:

Philosophical Society of Washington, O. H. GISH
Anthropological Society of Washington, MATTHEW W. STIRLING
Biological Society of Washington, CHAS. E. CHAMBLISS
Chemical Society of Washington, J. F. COUCH
Entomological Society of Washington, HAROLD MORRISON
National Geographic Society, F. V. COVILLE
Geological Society of Washington, H. G. FERGUSON
Medical Society of the District of Columbia, HENRY C. MACATEE
Columbia Historical Society, ALLEN C. CLARK
Botanical Society of Washington, NATHAN R. SMITH
Archaeological Society of Washington, WALTER HOUGH
Society of American Foresters (Washington Section), S. B. DETWILER
Washington Society of Engineers, PAUL C. WHITNEY
American Institute of Electrical Engineers (Washington Section), HERBERT G. DORSEY
American Society of Mechanical Engineers (Washington Section), HERBERT N. EATON
Helminthological Society of Washington, G. STEINER
Society of American Bacteriologists (Washington Section), H. W. SCHOENING
Society of American Military Engineers (Washington Post), C. H. BIRDSEYE
Institute of Radio Engineers (Washington Section), J. H. DELLINGER

On motion, the recording secretary was instructed to cast the vote of the Academy for the nominees, and they were declared elected.

President TUCKERMAN appointed past presidents WETMORE and ADAMS to escort Dr. MCCOY to the Chair. President MCCOY made a brief address and declared the meeting adjourned.

CHARLES THOM, *Recording Secretary*

ANTHROPOLOGICAL SOCIETY

The Anthropological Society of Washington at its annual meeting held on January 15, 1935, elected the following officers for the ensuing year: *President,* MATTHEW W. STIRLING; *Vice-president,* FRANK H. H. ROBERTS, JR.; *Secretary,* FRANK M. SETZLER; *Treasurer,* HENRY B. COLLINS, JR.; *Vice-President of the Washington Academy of Sciences,* MATTHEW W. STIRLING; *Members of the Board of Managers,* C. W. BISHOP, G. S. DUNCAN, H. W. KRIEGER, T. D. STEWART, W. D. STRONG.

A report of the membership and activities of the Society since the annual meeting held on January 16, 1934 follows:

Membership:

Life members	3
Active members	45
Associate members	8
Honorary members	18
Corresponding members	18
Total:	92

Deceased:	
Active members	1
New Members:	
Active members	1
Associate members	1
Total:	2

The Society lost through death one of the oldest and most devoted active members, Mr. FELIX NEUMANN, February 7, 1934.

Members elected during the year were: Dr. W. M. COBB and Mr. W. J. WINTER.

The financial statement (Treasurer's report) is as follows:

Funds invested in Perpetual Building Ass'n	$1170.43	
21 shares Washington Sanitary Improvement Co., par value $10 per share	210.00	
2 shares Washington Sanitary Housing Co., par value $100 per share	200.00	
Cash in bank	228.37	
Total	$1808.80	
Bills outstanding:		
To American Anthropological Ass'n	$50.00	
To Printer	3.75	
Total	53.75	53.75
Net Balance		$1755.05

Papers presented before the regular meetings of the Society were as follows:

January 16, 1934, 649th regular meeting, *Indian food plants and their historical significance*, by W. T. SWINGLE, Bureau of Plant Industry, U. S. Department of Agriculture.

February 20, 1934, 650th regular meeting, *The historical implications of Some Algonquian Studies*, by T. Michelson, ethnologist, Bureau of American Ethnology.

March 20, 1934, 651st regular meeting, *Future problems in anthropology*, by A. HRDLICKA, curator of physical anthropology, U. S. National Museum.

April 17, 1934, 652nd regular meeting, *Some laws of the early Iroquois league*, by President J. N. B. Hewitt, ethnologist, Bureau of American Ethnology, who gave his retiring address.

October 16, 1934, 653rd regular meeting, *Louisiana relatives of the Ohio* mound builders, by F. M. SETZLER, assistant curator, Division of Archeology, U. S. National Museum.

November 20, 1934, 654th regular meeting, *Archeological explorations in northeastern Honduras*, by W. D. STRONG, archeologist, Bureau of American Ethnology.

December 18, 1934, 655th regular meeting, *How the northern Indian hunts*, by J. M. COOPER, Catholic University of America.

All regular meetings, except the 651st, were held in Room 43 of the U. S. National Museum.

FRANK M. SETZLER, *Secretary*.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

The Great Drought of 1934.—Just how bad the Great Drought of 1934 was, has been made the subject of a special study by meteorologists of the U. S. Weather Bureau. All sections of the country, except along the Atlantic coast, the east Gulf area, and the Pacific Northwest, had below normal rainfall and much of the country had either the lowest of record or the total for the year approximated the previous low, Mr. Kincer states. Colorado, Indiana, North Dakota, Ohio, and South Dakota had the least annual rainfall of record, while Kansas, Montana, Nebraska, New Mexico, Utah, and Wyoming had only about one inch more than their previous low record. Thus approximately one-fourth of the States had in 1934 either the least precipitation of record or the annual totals approximated the previous low. Only one-third of the States had as much as normal. Almost as important as the rainfall in producing unfavorable weather effects were the high temperatures, especially during the growing season, which made less effective the rain that did occur. It was an abnormally warm year everywhere, except locally in the Northeast. A large northwestern area had the warmest year of record with some localities showing an accumulated excess of temperature as great as 2,000 degrees, or an average daily excess of nearly 6 degrees.

U. S. Public Health Service.—A sharp outbreak of cerebrospinal meningitis, fortunately not long-lived, occurred in the F.E.R.A. transient camps in Washington and Fort Eustis, Va., early in February. Hygienic and quarantine measures recommended by officers of the U. S. Public Health Service were put into effect and brought the epidemic under control.

Experiments by Dr. Charles Armstrong of the National Institute of Health have shown that mice can be made resistant to encephalitis of the *St. Louis 1933* type by dropping into their noses, at seven-day intervals, a three per cent solution of sodium alum. This experimental work, he states, "suggests lines of study which may possibly lead to the development of procedures of practical value in preventing infections contracted by way of the nasal mucous membranes."

Legislation for the promotion of national economic security, now pending before Congress, provides for $10,000,000 to be expended in public health work, of which $2,000,000 is earmarked for basic research.

Geological Survey.—Continuing the series of brief reports being sent to State Geologists, there has been transmitted an article on the copper and iron deposits of Virginia, describing recent work under a Public Works allotment. These deposits have been mined intermittently for at least 150 years. First the rich oxidized iron ores were smelted in crude furnaces. Later, methods of iron production improved until a generation or two ago Virginia was one of the leading producers of iron. Concomitantly with the increased iron output, the rich copper ores at water-level were exploited. Now practically all that remains are the original masses of iron sulphide, carrying inconsequential amounts of gold and copper, but these form a large potential reserve of raw material suitable for the manufacture of sulphuric acid.

National Bureau of Standards.—Dr. L. B. Tuckerman of the mechanics

and sound division has been asked to deliver the Edgar Marburg Lecture for 1935 at the annual meeting of the American Society for Testing Materials in Detroit next June.

Dr. W. W. COBLENTZ embarked on January 31 for a month's stay in Porto Rico where he is to advise at their school of tropical medicine on methods and equipment for measuring the solar ultra violet radiation useful in therapeutics. He will also carry on personal research on the measurement of the solar ultra violet radiation at this tropical station.

Children's Bureau U. S. Department of Labor.—The rickets studies carried on by the United States Children's Bureau in collaboration with the Pediatric and Surgical Departments of the Yale School of Medicine, have included a clinical investigation of the relation of rickets to defective formation of teeth and to the occurrence of dental caries, the results of which have been described by MARTHA M. ELIOT, M.D. and SUSAN P. SOUTHER, M.D., of the Children's Bureau, and BERT G. ANDERSON, D.D.S. and SUMTER S. ARNIM, D.D.S., of New Haven. The data assembled in this study indicate that enamel hypoplasia of the permanent teeth, especially the type characterized by a symmetrical distribution of defects in those teeth which are forming during infancy and early childhood, is frequently associated with rickets; that the more severe the rachitic process the more frequently do hypoplastic defects develop; and that, conversely, when severe hypoplasia was found, a definite history of moderate or severe rickets was established in nearly all cases by roentgenologic evidence. Dental caries too was found more often in children with a known history of rickets. Howtory, since caries appeared more often in teeth with hypoplastic defects than in those with none, it is possible that the latter relationship may account for the former. The data showed that children who have had several of the severe infectious diseases of childhood (including pneumonia and bronchitis) tend to have defects in the enamel more often than children who have had fewer of these diseases.

U. S. National Park Service.—There appears to be a definite move on the part of interested organizations and individuals to change the status of the Olympic National Monument to that of a national park, and with this possibility in view the National Park Service is carrying on some careful surveys in the area in order to have a full knowledge of the Olympic elk and its migrations before attempting to define boundary lines.

Smithsonian Institution.—The National Zoological Park will receive substantial additions and improvements to its housing accommodations through an allotment of $680,000 of PWA funds announced January 16 by Secretary of the Interior ICKES. Contemplated changes thus far announced by Director WM. M. MANN include an addition to the bird house, a new elephant house, and a house for the small mammals, with special accommodations for the apes. The elephant house and pens will be turned over to the hippopotamus and the rhinoceros, at present in rather limited quarters. To meet an urgent need of the Zoological Park, a machine shop will also be built.

Evidence that the practice of sacrificing a woman before going on the warpath was a widespread practice among North American tribes has been uncovered by Dr. TRUMAN MICHELSON of the Bureau of American Ethnology. He has found traces of this custom in the literature relating to the

Ojibwas and Hurons. Hitherto it was supposed to have been confined to the Pawnee.

New specimens of piranha, the *Brazilian man-eating fish* of the natural history books, have been added to the National Museum collections by B. A. KRUKOFF.

Carnegie Institution of Washington.—The moon's mountainous surface will be used as an astronomical *yardstick* by Dr. EDISON PETTIT and members of the astronomical staff of the Mount Wilson Observatory, in an endeavor to obtain information about the surface of the planet Mercury. The percentage of radiant heat in total reflected radiation from the moon's surface varies with the lunar phases, it has been found. Radiological observations will be made on Mercury as it passes through its phases, and this recently acquired knowledge about the moon will be applied to the data thus obtained.

Important scientific messages from the Watheroo Magnetic Observatory in Western Australia to the Department of Terrestrial Magnetism are transmitted through radio station VK5HG in Southern Australia to amateur stations in the eastern United States whence they are received by the Department.

Dr. G. R. WAIT, of the Department of Terrestrial Magnetism, by invitation attended the 41st annual meeting of the American Society of Heating and Ventilating Engineers at Buffalo, New York, January 27–30, 1935, where he presented a paper on *Large-ion and small-ion content of air in occupied rooms* by himself and O. W. TORRESON.

Volcanoes in Central America are the objective of a two-man expedition from the Geophysical Laboratory, now in the field. The two volcanologists, Dr. J. W. GREIG and Dr. E. G. ZIES, expect to spend about three months in Salvador and Guatemala.

Dr. ALBERT F. BLAKESLEE, Acting Director of the Department of Genetics of the Carnegie Institution of Washington, located at Cold Spring Harbor, Long Island, was elected on January 28 a corresponding member of the Academy of Sciences of the Institute of France.

Helminthological Society of Washington.—The Proceedings of the Helminthological Society of Washington are now being published as a separate journal. It is devoted to the publication of notes and papers in helminthology and related fields and includes parasites of both plant and animal hosts. Those interested either as contributors or subscribers should communicate with the editor, JESSE R. CHRISTIE, Bureau of Plant Industry, U. S. Dept. of Agriculture, Washington, D.C.

Pan-American Union.—The meeting held February 10 by the Washington Chapter of the Pan-American Medical Association at the Legation of Panama was devoted to intestinal surgery. A meeting is being planned for March in Georgetown University in honor of Col. B. K. ASHFORD, who discovered that the so-called tropical anemia in Puerto Rico was really caused by hookworms, thus laying down the basis for a worldwide campaign against the disease. The officers of the Chapter are Dr. HENRI DEBAYLE, Charge d'Affaires of Nicaragua, president, Surg. Gen. ROBERT U. PATTERSON, vice-president, and Dr. A. A. MOLL, scientific editor of the Pan-American Sanitary Bureau, secretary.

Society of American Foresters.—The Society of American Foresters held its thirty-fourth annual meeting in Washington, January 28, 29, and 30. The afternoon session of Wednesday, January 30, was devoted to a symposium on forest fire control in the coastal plains section of the South. Participating were: A. B. Hastings, E. L. Demmon, W. G. Wahlenberg, S. W. Greene, I. F. Eldredge, H. L. Stoddard and Chaucey Kuehn. It was developed that scientific observations, mostly under control conditions where comparison with like unburned areas is possible, have shown that within reason fire is a good thing for longleaf pine. This species is fire-resistant in all except its first few months of life, because of its thick bark and its trick of protecting its all-important *leader* bud with a dense bundle of leaves. Fire kills less valued competing pines and hardwood species, and lets the young longleaf trees grow.

Fire, it has also been found, helps the longleaf seedlings against one of the most serious of pine diseases, the brown spot of their leaves. In one experimental area, young pines kept wholly protected from fire showed twice as much of this infection as did trees of similar age that stood on ground regularly burned over.

Fire appears also to be beneficial to the soil itself, and to the grass that grows among the trees, and thus to the cattle that eat the grass. Unburned areas, to be sure, did have soil somewhat more porous that that in burned areas; but this advantage was offset by the better chemical condition of the burned-over soil. Burned-over soil produced twice as much green weight of vegetation, which was also of better nutritive quality than the plants from unburned areas. And cattle grazed in burned-over woods gained more weight and were sleeker-looking than comparison herds kept in fire-free woods.

The common practice of burning the woods every spring is too much. Much less frequent use of fire is calculated to bring better results, in all probability. Tests of just how often the red demon can be invoked with benefit rather than harm are now in prospect.

News Briefs

Wild ducks are scarce in Mexico, no less than in this country. Investigators of the U. S. Biological Survey, who are studying certain duck species that nest in the United States and Canada and winter in Mexico, have learned from Mexican sportsmen, as well as from their own observations, that the serious duck shortage felt for some years in this country has its close reflection in our next-door neighbor on the south.

Four thousand acres of forest still in completely primeval condition, in the northwest part of Pennsylvania, have been acquired by the U. S. Forest Service and will be kept as a primitive area. The forest, known as the Tionesta tract, consists of a mixed stand of hardwoods and hemlocks. The tract is of historic as well as scientific interest, for it is the last uncut, unburned remnant of the wilderness that gave the colony founded by William Penn the name *Penn's Woods*—Pennsylvania.

Obituary

HARRY DRAKE GIBBS, consulting chemist, died December 28, 1934, after a brief illness, at Hyattsville, Maryland. He was born March 10, 1872, at Cincinnati, Ohio, and received his technical education at Rose Polytechnic Institute and Cornell University, obtaining the degree B.S. from the latter institution. Stanford University granted him the Ph.D. degree in 1913. He was assistant professor of chemistry, Oregon Agricultural College, 1901–3; research assistant, Stanford University 1904–5; chief chemist of the San Francisco Board of Health, 1905–7. The years 1907–14 were spent in the Philippine Islands where he held a series of important positions including chief, Food and Drug Inspection Laboratory; chief, Department of Chemistry, University of the Philippines; assistant to the director, Bureau of Science; and finally head of the Food and Drug Board of the Islands. Coming to Washington in 1914 as assistant chief, Eastern Food and Drug Inspection District, he became in 1915 chemist in charge of the Color Laboratory of the Bureau of Chemistry. During the war he served as head of the Division of Chemical Technology and Industrial Relations of the National Research Council. At this time he was also head of the Chemical Section of the Department of Science and Research, Bureau of Aircraft Production. Following the war he was research chemist, E. I. du Pont de Nemours & Co., 1919–22; senior chemist, National Institute of Health, 1922–29; and finally consulting chemist, 1929–34. In addition to the Washington Academy of Sciences, Doctor Gibbs was a member of the Philippine Islands Medical Association, American Chemical Society, Deutsche Chemische Gesellschaft, A.A.A.S., Delta Tau Delta and Sigma Xi. He was the author of numerous publications in his chosen field and the holder of a number of patents on chemical processes.

CHARLES DAVID WHITE, of the U. S. Geological Survey, died at his home, 2812 Adams Mill Road, Washington, D. C., February 7, 1935. He was born at Palmyra, N. Y., July 1, 1862, and received the B.S. degree from Cornell University in 1886, that same year joining the U. S. Geological Survey as assistant paleontologist. From that grade he advanced steadily to chief geologist in 1912, a position he filled until 1922. His latest title was that of principal geologist. Doctor White's early work was concerned with the fossil plants from the Cretaceous sediments occurring on the coastal plain from Virginia to Marthas Vineyard Island, but most of his life's work was concentrated on the paleobotanic, stratigraphic, and genetic problems connected with the origin and occurrence of coal and petroleum. Numerous papers on these subjects bear witness to his industry and productivity. At the time of his death he was engaged in an extensive study of the coal floras of Illinois and Oklahoma. Doctor White was honorary curator of fossil plants at the U. S. National Museum; research associate of the Carnegie Institution; and a member of many scientific societies, including the National Academy, American Philosophical Society, Geological Society of America, the American Association for the Advancement of Science, and the Washington Academy of Sciences. He was honored with the Sc.D. degree from the University of Rochester in 1923 and from Williams College in 1925. One of his recent awards was the Walcott medal in April, 1934, for his investigations of primitive life in early geologic strata.

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JOURNAL
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VOL. 25 APRIL 15, 1935 No. 4

GENERAL SCIENCE.—*Some interesting applications of deuterium.*[1]

F. G. BRICKWEDDE, National Bureau of Standards.

With practically all the elements having isotopes, many in much higher concentrations than deuterium, deuterium owes its importance first of all to the large percentage difference in mass of the two hydrogen isotopes—a difference of 100 percent. As a result all differences in properties depending on mass are much greater in the case of these isotopes than in case of the isotopes of any other element. In the second place deuterium owes its importance to the electrolytic method of separation by means of which it can be obtained in a pure state conveniently and rapidly.

The electrolytic fractionation of deuterium is itself a very interesting problem. The question as to why a separation does occur has not yet been settled, but from experimental and theoretical investigations of this process, we have a much better understanding than formerly both of the evolution of hydrogen at an electrode and of its overvoltage with respect to various metals. It can be definitely stated that this separation does not result from a difference in electrode potentials of hydrogen and deuterium, the difference here being much too small. Differences in mobilities of the ions or in their rates of diffusion will not account for it. It has been deduced that the evolution of hydrogen at an electrode takes place in two steps. The first consists of the discharge of a positive H^+ ion in solution and the adsorption on the metal electrode of the neutral H atom formed. From the energy changes involved, it has been shown that these two actions take place in one step. The second step is the formation of molecules

[1] Published with the approval of the Director of the National Bureau of Standards of the U. S. Department of Commerce. The contents of this paper were presented on February 16, before the 1080th meeting of the Philosophical Society as part of a paper entitled, *The uses of deuterium and the measurement of its vapor pressures.* The vapor pressure measurements are contained in *Vapor pressures and derived thermal properties of hydrogen and deuterium* by R. B. SCOTT, F. G. BRICKWEDDE, H. C. UREY and W. H. WAHL, Jour. Chem. Physics, **2**: 454. (1934), and in *The ortho- para-vapor pressure difference in deuterium* by F. G. BRICKWEDDE, R. B. SCOTT, and H. S. TAYLOR, to be published. Received Feb. 16, 1935.

from the adsorbed atoms and the desorption of the molecules from the electrode. Fractionation results from differences in the rates for hydrogen and deuterium of one or both of these two processes.

The use of deuterium enables us to do two very desirable things in chemistry. In the first place we can investigate the effect of mass

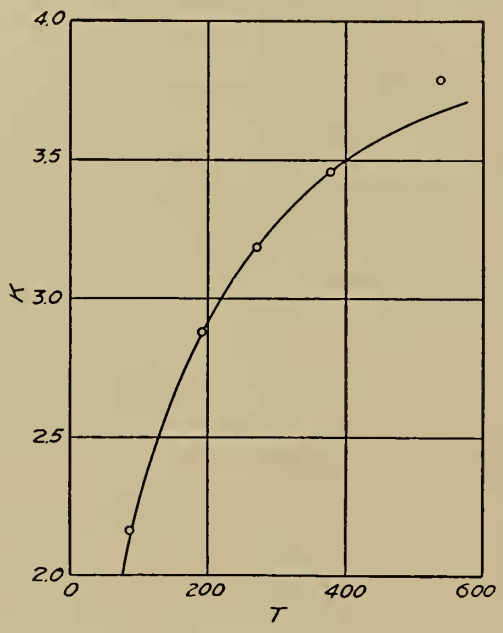

Fig. 1.—The equilibrium constant of the reaction, $H_2+D_2 \rightleftarrows 2HD$, as a function of the temperature in degrees Absolute.

independent of chemical nature upon equilibrium concentrations and rates of reaction. In the second place, hydrogen atoms taking part in chemical reactions can be tagged and distinguished from one another.

A reaction that has been extensively investigated is the reversible reaction of hydrogen with deuterium to form hydrogen-deuteride

$$H_2+D_2 \rightleftarrows 2HD.$$

The equilibrium constant of this reaction, K, a function of temperature, is

$$K(T) = \frac{[HD]^2}{[H_2][D_2]}$$

where [HD], [H_2], and [D_2] denote the concentrations of HD, H_2, and

D_2, respectively. In Fig. 1 are represented[2] the experimentally and theoretically determined equilibrium constants of this reaction. The curve representing the theoretical results was determined by the method for the calculation of thermodynamic quantities from spectroscopic data. Were it just as probable when H_2 and D_2 molecules collide for them to exchange atoms with each other to form HD molecules as it is for HD molecules to exchange atoms on collision to form H_2 and D_2 molecules, the equilibrium constant would be 4. It is seen, however, that the probability of exchange is greater for HD than for H_2 and D_2 and the concentration of HD is less than would be expected from the statistics of collisions. The underlying physical reason for the difference in the probabilities of the exchanges is the difference between the zero point energies of these three molecules, i.e., the difference between their energies at the absolute zero of temperature. When H and D atoms combine with each other, they form H_2, D_2 and HD in concentrations given by this equilibrium constant, $K(T)$. We see then that on collision H and D atoms prefer to unite with their own kind rather than to mix.

Other reactions have been investigated and the theory for the calculation of thermodynamic quantities is substantiated. To know this is important, because the experimental measurement of equilibrium concentrations is very difficult and can not be carried out with the precision or accuracy with which the constants can be determined theoretically.

The rates at which hydrogen and deuterium react with other substances are being studied. In the calculation of the rates at which substances react, factors enter that are not well understood, and satisfactory computations of reaction rates are not possible. Through investigations of the comparative rates of hydrogen and deuterium with other substances, an effort is being made to determine the effect of mass on reaction kinetics. In most cases, the rates with hydrogen are greater than with deuterium. The rates for three interesting reactions are:

$$\frac{\text{rate of } H_2+Br_2\rightarrow 2HBr}{\text{rate of } D_2+Br_2\rightarrow 2DBr} = 5.0 \qquad \text{at } 308°\text{C}.$$

$$\frac{\text{rate of } H_2+Cl_2\rightarrow 2HCl}{\text{rate of } D_2+Cl_2\rightarrow 2DCl} = 13.4 \qquad \text{at } 0°\text{C}.$$

[2] This Figure and Tables I, II, and III were taken from *Hydrogen isotope of atomic weight two* by H. C. Urey and G. K. Teal, Rev. of Modern Physics, 7: 34. (1935).

$$\frac{\text{rate of } H_2+Cl_2\rightarrow 2HCl}{\text{rate of } D_2+Cl_2\rightarrow 2DCl} = 9.8 \quad \text{at } 32°C.$$

$$\frac{\text{rate of } 2H_2+O_2\rightarrow 2H_2O}{\text{rate of } 2D_2+O_2\rightarrow 2D_2O} = 2.5 \quad \text{at } 560°C.$$

To demonstrate the usefulness of deuterium in tagging or distinguishing hydrogen atoms let us consider the simple reaction that takes place when ammonia is dissolved in water:

$$NH_3+H_2O\rightleftharpoons NH_4OH.$$

Ammonium hydroxide is formed and since the reaction is reversible this decomposes into NH_3, dissolved, and H_2O. Now it is of interest to ask whether or not the same three H atoms are attached to the N atom of an ammonia molecule after the decomposition of NH_4OH as were originally attached to it. Or it may be asked if the four H atoms attached to the N of an NH_4OH molecule are equivalent. Let us consider what should happen if we dissolve ammonia in D_2O. If the four H atoms attached to the N of NH_4OH are not equivalent and the same three original H atoms are attached to the N atom after the decomposition of ammonium hydroxide, the following reaction will take place:

$$NH_3+D_3O\rightarrow NH_3DOD\rightarrow NH_3+D_2O.$$

There will be no exchange of the hydrogen of the ammonia with the deuterium of the water. If, however, the four H atoms attached to the N are equivalent then the following reactions will occur:

$$NH_3+D_2O\rightarrow NH_3DOD\rightarrow NH_3+D_2O$$
$$NH_3DOD\rightarrow NH_2D+HDO,$$

and as a result the D and H atoms of the water and ammonia will mix. Experiment shows that they do mix and that when equilibrium is reached, the relative concentrations of hydrogen and deuterium atoms in the water and ammonia are the same. This shows that all three hydrogen atoms of ammonia are in exchange with hydrogen atoms of the water.

In Tables I and II are tabulated a number of exchange reactions.

In the field of physiological chemistry, this ability to tag hydrogen atoms should prove useful. For example we can determine how rapidly a drug taken into the system is absorbed by the blood stream and then eliminated. This can be done by replacing some of the H atoms of the drug with deuterium and then analyzing for the drug by de-

TABLE I.—Exchange Reactions between Water and Organic Compounds

Compound	Observation
CH_3COONa	No exchange
CH_3COOH	" "
CH_3CHO	1 hydrogen atom exchanges slowly
CH_2O	2 hydrogen atoms exchange slowly
CH_3COCH_3	Very slow exchange in neutral solution Faster exchange in acid solution Very fast exchange in alkaline solution
$CH_3COCH_2COCH_3$	All hydrogens exchange
C_2H_2	Exchange in alkaline solution
Glucose and Cane Sugar	Hydroxyl hydrogens exchange immediately
$(CH_2OH)_2$	One-third of hydrogens exchange immediately
Egg albumen	All hydrogens attached to N atoms exchange
Cellulose	All hydroxyl hydrogens exchange

TABLE II.—Inorganic Exchange Reactions

Reaction	Observation
$H_2(g) \rightleftharpoons H_2O(l)$ and (g)	Exchange in presence of platinum Exchange observed in 6 weeks without addition of catalyst No exchange observed in 19 days without catalyst Exchange in 1–9.5 hours under 340–370 atmospheres pressure Exchange observed without catalyst in Pyrex and quartz vessels at 800° Abs.
$H_2(g) \rightleftharpoons HI(g)$	Exchange observed at 400°C and above
$H_2(g) \rightleftharpoons HCl(g)$	Exchange in presence of palladium at 180°C
$H_2O(l) \rightleftharpoons NH_4^+$ (*sol.*)	All hydrogen atoms exchange
$H_2O\ (l) \rightleftharpoons NH_3(l)$	All hydrogen atoms exchange
$H_2(g) + D_2(g) \rightleftharpoons 2HD(g)$	Exchange at high temperatures and on catalytic surfaces. Ni, chromium oxide, Pd, Hg, Pyrex and soft glass, and charcoal at liquid air temperatures do not promote exchange
$KH_2PO_2 \rightleftharpoons H_2O$	No exchange
$[Co(NH_3)_6](NO_3)_3 \rightleftharpoons H_2O$	All hydrogens exchange

termining the D content of the blood. Of course the exchange reactions of the drug must have been previously investigated.

The usefulness of deuterium in biological chemistry can be illustrated by another example. Sodium formate is decomposed by enzyme hydrogenlyase of *Bacterium coli* with the formation of hydrogen and carbon dioxide. The mechanism of decomposition previously accepted for this was:

$$HCOONa + H_2O \rightarrow HCOOH + NaOH$$

$$HCOOH \rightarrow H_2 + CO_2.$$

If this is correct then replacing H_2O with D_2O the following reaction would result:

$$HCOONa + D_2O \rightarrow HCOOD + NaOD$$

$$HCOOD \rightarrow HD + CO_2.$$

No H_2 or D_2, but only HD would be formed.

Experiment shows that H_2, D_2 and HD are evolved in the equilibrium concentrations presented in Fig. 1. Moreover it has been found that in a gaseous mixture of H_2 and D_2 over water the *Bacterium coli* acts like Pt-black as a catalyst in establishing an equilibrium between H_2, D_2 and HD. It must be concluded that the previously supposed mechanism of the decomposition is not correct and that the *Bacterium coli* can react with hydrogen in the atomic form. It therefore seems probable that the decomposition of the formate by *Bacterium coli* occurs through atomic reactions with the formation of H and D atoms.

Because of the extreme sensitiveness of certain biological reactions to changes in environment, it was early realized that isotopic water might produce marked changes in many cases. At first biological effects of high concentrations of D_2O were observed by some chemists. The striking observations of *drunk* mice, the failure of tobacco seeds to sprout, and the death of guppy fish and tadpoles in D_2O, were reported. Fermentation by yeast cells was found to be so much slower that bread made with heavy water would take about one week to rise.

Later, biologists realizing that experiments carried out with low concentrations of deuterium should be more significant biologically in determining the effect of deuterium under approximately normal conditions, subjected various organisms to water containing 0.5 percent and less of D_2O. All experimenters have not found the same effects. It has been reported that *Spirogyra*, or pond scum, lives twice as long in 0.06 percent D_2O, and that some flatworms, *Phagocata gracilis*, placed in ordinary water without food shrank to 1/5 their size in five months, whereas in 0.06 percent heavy water there was only a slight diminution in size. It has also been reported that the growth of *Aspergillus niger;* the germination of conidia of the powdery mildew of wheat, *Erysiphe graminis tritici;* the root growth of wheat and the O_2 consumption by wheat seedlings showed no significant difference between the influence of ordinary water and that of water containing 0.05 and 0.5 percent D_2O. Other experiments, however, indicated that in the case of some bacteria low concentrations of D_2O—of the order of 0.5 percent—have a stimulating effect on the rate of oxygen absorption, whereas in high concentra-

tions—approaching 100 percent—the reverse is true, the rate of oxygen absorption being decreased.

In the field of nuclear physics deuterium has found one of its most important applications. It has added to the material particles used in the investigation of the structure of the nucleus, namely, the proton, neutron and α-particle, another, the deuteron (deuterium nucleus) which can be given great speeds in high voltage tubes and then used to bombard and transmute nuclei of other elements. In some respects the deuteron has proved to be more interesting than the proton. The highest energy material particles ever produced in a laboratory under controlled conditions are the helium nuclei resulting from the bombardment of Li^6 with deuterons. (The superscript designates the atomic weight of the isotope.) The two helium nuclei formed by this nuclear reaction

$$D^2 + Li^6 = 2He^4$$

have ranges in air of 13.2 cm. This is greater than the range of the longest α-particles from any of the radioactive elements. It would require 23,000,000 volts to give them their observed speeds. The transmutations resulting from the bombardment of deuterium with deuterons is unique in that it is the only known case in which a transmutation results from the bombardment of a particle with an identical particle. Two nuclear transformations can take place

$$D^2 + D^2 = T^3 + H^1$$
$$D^2 + D^2 = He^3 + \text{neutron}.$$

The symbol T denotes tritium, the hydrogen isotype of atomic weight 3. The first of these is the most abundant of all known nuclear reactions, i.e., a far greater number of transformations result per million bombarding particles than in the case of any other known reaction. The first reaction is the only one known in which another isotope of the same element is formed, instead of another element. In the strict sense of the word this is not a transmutation.

In the production of artificial radio-activity, deuterium surpasses α-particles and protons in effectiveness. It is reported that high speed deuterons render 14 of the lighter elements (Li, Be, B, N, C, O, F, Na, Mg, Al, Si, P, Cl and Ca) radioactive emitting positive electrons in their disintegration. Of these elements only B and C become radioactive under proton bombardment.

Just as deuterium made possible the investigation of the effect of mass apart from chemical nature upon chemical properties, it makes

possible the investigation of mass upon physical properties. Previously this was not possible. The change in physical properties due to difference in mass in going from one element to another is far overshadowed by the change due to the difference in chemical nature. A *pure* effect of mass on physical properties is illustrated in Table

TABLE III.—PROPERTIES OF H_2O AND D_2O

Property	H_2O	D_2O
Density$_{25}^{25}$	1.0000	1.1079
T of maximum density	4.0°C	11.6°C
Molar volume at temperature of maximum density	18.015 cm^3	18.140 cm^3
Lattice constants of ice a	4.525A	4.505A
b	7.39A	7.36A
Volume of the ice cell	131.0A^3	129.3A^3
Mole volumes of the ices 0°C	19.65 cm^3	19.32 cm^3
Dielectric constant	81.5	80.7
Surface tension	72.75 dynes/cm	67.8 dynes/cm
Viscosity in millipoises 10°C	13.10	16.85
20°C	10.09	12.60
30°C	8.00	9.72
Molar magnetic susceptibility liquid at M.P.	12.93	12.66
solid at M.P.	12.65	12.54
at 20°	12.97	12.75
Refractive index 20°C NaD line	1.33300	1.32828
Molar refraction 20°C NaD line	3.7121	3.665
Verdet constant $\lambda = 5893$A	0.013067	0.012556
Min./gauss·cm $\lambda = 5460.7$A	0.015395	0.014793
M.P.	0.0	3.802
B.P.	100.0	101.42
Heat of fusion	1436 cal.	1510 cal.
Heat of vaporization 25°C	10484 cal.	10743 cal.
Equivalent conductance at 18°C	H^+ in H_2O 315.2	D^+ in D_2O 213.7
K^+	64.2	54.5
Cl^-	65.2	55.3
Solubilities, molalities		
NaCl 25°C	6.145	6.145×0.92
$BaCl_2$ 20°C	1.72	1.72×0.88

III in which the properties of H_2O and D_2O are compared. The difference between the values of these properties for H_2O and D_2O are larger than was expected and as yet are not quantitatively explained.

The effect of mass is even more striking in the case of molecular hydrogen and deuterium at low temperatures. The boiling and freezing point temperatures, in degrees absolute, of hydrogen and deuterium and their corresponding vapor pressures are given in Table IV. Table V contains the latent heats of transition and the densities of the solids.

At the freezing point of hydrogen, 13.92° Abs., the vapor pressure of solid deuterium is only 5 mm of Hg or 1/11 of that of solid hydrogen. Before the vapor pressure of deuterium was measured it

TABLE IV.—Boiling and Freezing Points

	T in Degrees Absolute	Vapor Pressure mm of Hg	
		H_2	D_2
Boiling point of deuterium	23.59° Abs.	1753	760.0
Boiling point of hydrogen	20.38	760.0	256.2
Freezing point of deuterium	18.71	447.5	128.7
Freezing point of hydrogen	13.92	54	5.2

TABLE V.—Molecular Volumes and Latent Heats of Transition

	H_2	D_2
Volume of 1 gram molecule weight of solid	26.15 cm^3	23.15 cm^3
Heat of fusion	28 cal/mol	47 cal/mol
Heat of vaporization of liquid at 20.38° Abs.	216 cal/mol	307 cal/mol

was calculated from theory. The theory predicted that at this temperature the vapor pressure of deuterium would be 16 mm or only a little less than 1/3 of that of solid hydrogen. The observed values were introduced in the theoretical equations, and quantities were derived which could be compared with the results of other experiments. Assuming the validity of the vapor pressure theory, it was shown that the coefficient of expansion of solid hydrogen must be abnormally large and that for solid deuterium small. From the derived data, the specific heat at constant volume for solid hydrogen, a quantity which is difficult to measure and previously unknown, was calculated. In Table VI are listed values of the specific heats at constant pressure, C_p, and at constant volume, C_v. For solid hydrogen at 14° Abs. $C_p - C_v$ is 2 times C_v, and at 10° Abs., 2.7 times C_v, whereas for most solids the difference between C_p and C_v is negligibly small in comparison with C_v. This anomaly in solid hydrogen is a consequence of its large coefficient of expansion.

TABLE VI.—Specific Heats of Solid Hydrogen at Constant Pressure and Constant Volume

T Degrees Absolute	C_p Observed	C_v Calculated
10° Abs.	0.59 cal/mol	0.16 cal/mol
13.92	1.32 cal/mol	0.42 cal/mol

The differences between the physical properties of hydrogen and deuterium and their compounds are in general larger than was expected. In cases where the differences have been accounted for, new or further knowledge concerning hydrogen itself has been acquired.

As an example: It has been learned from a comparison of the vapor pressures of hydrogen and deuterium that solid hydrogen has an unusually large coefficient of expansion, and that for solid hydrogen $C_p - C_v$ is much larger than C_v itself, whereas in the case of most solids, the difference is negligibly small.

This new line of isotopic research in physics will not stop with deuterium but will be extended to the isotopes of other elements. Experiments are already under way to separate the isotopes of Ne, C, N and O in quantities large enough to determine their physical and chemical properties.

The observed differences between the biological, chemical and physical properties of hydrogen and deuterium and their compounds appear all the more striking when we recall the time when it was thought that all properties, reduced to the gram molecular basis, with the exception of those properties which depend upon the velocity of motion of the molecules, as the viscosity of a gas, were the same for all isotopes of the same element. Indeed Soddy, the discoverer of isotopes, does not call deuterium an isotope of hydrogen, because he looks upon the indistinguishability of properties, reduced to the gram molecular basis, as an essential characteristic of isotopes. It must be conceded to Soddy that hydrogen and deuterium behave like different substances but we have today a more fundamental definition of isotopes and a better understanding of the effect of mass on physical and chemical properties. As Lord Rutherford has put it, "much water has flowed under the bridge" since Soddy's discovery of isotopes in 1913.

GEOLOGY.—*Pre-Devonian structural zones in Scotland and eastern North America.*[1] ANNA I. JONAS, U. S. Geological Survey. (Communicated by W. W. RUBEY.)

Scotland, although covering a small area, about 40 miles wide and 250 miles from north to south, is of great interest geologically because it contains parts of several pre-Devonian belts of sedimentation with a complicated tectonic history. The structures which trend both northwestward and northeastward are cut off abruptly at the coast in both directions and their continuations have been sought in adjoining lands, Fennoscandia, Spitzbergen, and Greenland.

This brief discussion is based largely on the work of others and is given as the result of my participation in the second excursion of the

[1] Published by permission of the Director, U. S. Geological Survey. Received January 5, 1935.

Pre-Cambrian Association held in Scotland August 18, 1934, under the leadership of Professors Bailey, McCallien, Read and Tilley. "The International Association for the study of the pre-Cambrian and Old Mountain Chains," as it is called, was organized by Sederholm in 1930 and holds its excursions the year following the meetings of the International Geological Congress. The next field meeting will be in Czechoslovakia under the leadership of Radium Kettner of Prague. An account of the present position of the organization of the Pre-Cambrian Association and of the second excursion was published in December, 1934 (1).[2]

Pre-Devonian rocks of Scotland.—Scotland is made up from south to north of the Southern Upland, the Midland Valley, and the Highlands. The last major folding was pre-Devonian, Caledonian, in age, and all younger rocks show relatively unimportant disturbances. The Midland Valley, occupied by down-faulted Devonian and Carboniferous rocks and their intrusives and extrusives, separates the folded belts of the Southern Upland and the Highlands. The Southern Upland contains Ordovician and Silurian rocks. The Highlands are divided into 3 parts; the Southern and Central Highlands contain the Moine and Dalradian Series, both metamorphosed and folded, as were the rocks of the Southern Upland, during Caledonian orogeny. The Southern Highlands are separated from the Midland Valley south of them by a normal fault, the Highland border fault. The Central Highlands is cut in two by the Great Glen which extends along another normal fault, the Glen fault of Jurassic or younger age. The Caledonian canal follows the Glen and connects Loch Linnhe on the southwest with Loch Ness on the northwest.

In the Northwestern Highlands the Moine series has been thrust northwestward over the rocks of another orogenic belt. These rocks include the Lewisian basement of early pre-Cambrian age, composed of an igneous complex intruded into metamorphosed schists and marbles, and is overlain unconformably by late pre-Cambrian Torridonian sandstone. Both series of pre-Cambrian rocks are overlain unconformably by Lower Cambrian quartzites and the Durness limestones whose resemblance to rocks of the same age in the Appalachian Valley will be discussed later.

Moine thrust.—The Moine thrust (2) and its branches forming lower planes of disruption, the Glencoul and Ben More thrusts, produce a belt of imbricate structure 6 to 8 miles broad lying east of an undisturbed tract of Torridon sandstone and Lewisian rocks. The Moine

[2] Numbers refer to the Bibliography given at the end of this paper.

gneiss and the Lewisian igneous complex on the soles of the overthrusts have been ground out into mylonite gneisses and mylonites which were recognized and defined by Lapworth in this area in 1885. These mylonites on the Moine and Glencoul thrusts are well exposed near Knockan and on the shores of Loch Glencoul. The unravelling of the stratigraphy and tectonics of this complicated region is a monument to two great Scottish geologists, Peach and Horne (3).

Undisturbed rocks northwest of Moine thrust.—The Lewisian igneous rocks are well exposed on the shore of Loch Assynt to the Coast at Lochinver and are in large part a light and dark-banded gabbro with pink granite layers. It is a primary gneiss and according to Eskola, a product of the first crystallization of a basic magma followed by differentiation and later intrusion of the types of medium and acid composition. The gneiss is cut by ultrabasic dikes, and contains shear zones which strike northwest across the flow banding of the gneiss which is crushed to a mylonite or augen gneiss in the disturbed zones. The Lewisian gneiss (4) is exposed along the northwest coast of Scotland and in the Isle of Lewis in the Hebrides and all the igneous intrusion and folding in that area was early pre-Cambrian, pre-Torridonian, and the Torridon sandstone was deposited on the deeply eroded surface of this old land area. This sandstone series, which resembles the Triassic of the eastern United States and the Devonian of Scotland, was called Devonian before it was found that Lower Cambrian rocks unconformably overlie it. It also resembles the Jotnian sandstone of Finland and the Sparagmite formation of Norway, the youngest pre-Cambrian rocks of Fennoscandia. The folded structures of the Lewisian gneiss trend west and northwest while all younger rocks of Scotland trend northeastward. Suess (5) and others have suggested that the Lewisian basement belongs to Laurentia and in pre-Cambrian times was connected with the Canadian Shield by way of Greenland, and the whole was part of Eria, an inferred northern continent.

The crystalline schists of Loch Maree into which the granite-gabbro complex of the Lewisian was intruded, have been compared to those of the Grenville. The Lewisian igneous complex where I saw it on the shores of Loch Assynt bears a striking resemblance to the igneous complex of the Reading-Boyertown Hills in eastern Pennsylvania, which lie in the Highland belt of the Appalachian Mountains. The excursion did not visit Loch Maree and therefore I can make no comparison of the sedimentary Lewisian schists with the crystalline schists into which the igneous rocks of the Reading-Boyertown region

are intruded. The Lower Cambrian rocks of northwestern Scotland are lithologically like those in the main Appalachian Valley. The fauna in the two areas also is the *Olenellus* fauna of Arctic type.

Relations of the pre-Devonian Highland rocks southeast of the Moine thrust to those of other areas.—The rocks of the Moine and Dalradian series have only thrust relations with the rocks of Northwestern Scotland, and since they contain no fossils, their age and relations are not definitely known. The Moine series (6), composed of siliceous gneisses and schists, is considered to be pre-Torridonian by Clough, Horne, Gregory, Read, and Eskola, and to be Lewisian by Barrow and Read, and metamorphosed Torridonian by Bailey. It was intruded by the Older granites of the Inchbae and Carn Chuinneag complex (7), perhaps of pre-Cambrian age, before it was folded and metamorphosed. The Moine series at the contact with these intrusives is a hornfels with its current bedding preserved. Later deformation has affected both the intrusives and the Moine in zones striking across their contacts. Read believes that the metamorphism of the Moine series is not Caledonian because the Moine gneisses were metamorphosed before the intrusion of the Ben Loyal alkaline rocks, which are thought to be Ordovician and equivalent to the syenite rocks of the Loch Borolan area where they intrude the Durness limestones of Cambro-Ordovician age. The dislocation metamorphism along the Moine thrust has affected both the syenite and Moine gneisses. The Newer granites, of Silurian age, the Helmsdale granite, Rogart diorite, and the Strath Halladale injection (8) complex also were intruded into the Moine series after the metamorphism. At Cnok na Bieste zenoliths of Moine mica schist are included in the Strath Halladale granite and sillimanite is developed in the adjoining Moine schist. The large granite intrusions near Aberdeen belong also to the Newer granites.

The Dalradian series of quartzites, limestones, slates, and schists overlies the Moine, in part of the Highlands south of the Great Glen fault and extends to the Southern Highland border fault. Bailey believes that it is a pre-Cambrian series, younger than the Moine and overlies it, and that it was metamorphosed and folded and thrust during Caledonian orogeny into four great nappes (9). These structures the members of the excursion studied in the Appin Country south of Loch Linnhe where the Dalradian is not much metamorphosed. The more metamorphosed Dalradian described by Tilley (10) occurs in the Southern Highlands farther south and southwest of Loch Linnhe.

Robert Campbell and other Scottish geologists recognize that the Dalradian series may be Paleozoic and perhaps the metamorphosed equivalent of the folded Ordovician and Silurian rocks of the Southern Upland. This area contains no lower Cambrian rocks but was folded during Caledonian orogeny. In Western Norway where Caledonian folding has been recognized also, a metamorphosed clastic series of Cambrian and Ordovician rocks, first described by Störmer at Ustaoset in 1925, appears in the Bergen arches and has been compared by Kolderup to the Dalradian series. It carries Cambrian fossils of the Fjeld facies of the Baltic type which occurs also in the larger Cambrian belt on the border of Sweden and Norway. In Sweden, east of the border area of Lower Cambrian, is the black carbonaceous shale type of Cambrian of the normal facies of the Baltic type (*Olenus* fauna) which appears in the Midlands of England, in Wales and in Eastern North America in Eastern Newfoundland, Nova Scotia and the Boston area. This type of Lower Cambrian in Sweden and Great Britain lies south and east of the Caledonian orogeny and is not folded. The age of the Upper Cambrian Kolm of the normal series has been determined on the basis of its lead ratio as 425 million years (11).

Southern England was involved in a younger orogenesis than the Caledonian, the Armorican (Hercynian) of Pennsylvanian age, which extends into Western Europe south of the Baltic shield. It contains Mediterranean facies of the Atlantic Province not found in Eastern North America.

Caledonian folding has been recognized not only in Scotland and western Norway and Sweden but its continuation has been found in Spitzbergen and perhaps in northern Greenland. In each country the folded belt is cut off by the sea but similar formations and sequence of diastrophism appear across the water. Holtedahl (12) and other workers have established the Caledonides in Spitzbergen. Koch (13) refers the folding in northern Greenland to the Caledonian in the region between 80° and 83° North Latitude where it extends north of Pearyland across Grantland and Elsemereland on the north side of the pre-Cambrian basement that forms central Greenland. The faunas in northern Greenland are Appalachian, Arctic in type, hence belong to another trough from that of the Caledonian folded belt of Scotland and Norway. Thorolf Vogt and Resser therefore question the extension of the Caledonides to northern Greenland.

Orogenic interpretations of the structure of Scotland.—In Norway and Sweden, according to Vogt and others, the direction of movement

in the Caledonian folding is southeastward towards the Baltic Shield. Franz E. Suess (14) regarded the major direction of the movement as also southeastward. Bailey considers the Dalradian series as in part overlying the Moine, but Suess, on structural and metamorphic grounds, regards their contact as plane of dislocation. He suggests also that the Moine was the creative block which overrode southeastward over the Dalradian series which were back folded on the Moine in the process. He regards the folded non-metamorphic Paleozoic rocks of the Southern Uplands as part of the outer zone of the movement where directed pressure and not load was operative. The Baltic Shield was the foreland for the movement in Scandinavia, but in Great Britain none of the foreland is exposed.

The Moine thrust in northwestern Scotland cuts obliquely across Caledonian structure and Suess (14) believes the Moine thrust is independent of it and younger. He suggests that the Moine thrust has moved northwestward with a greater transport than is apparent and carried the rocks of the main Caledonian trough over the northwestern belt in which there are rocks of another sedimentary trough. In other words, the Caledonides are a one-sided orogen with Fennoscandia as their foreland and the northwestern movement of the Moine thrust is an unrelated and later event.

Early Paleozoic troughs of Scotland and of the eastern United States.—In the early Paleozoic, as has been said, there were two troughs of deposition in Scotland,—the northwestern with an Arctic fauna, the same as that of the main Appalachian belt, and a southern trough with a Baltic facies of the Atlantic Province. It is probable that these troughs were separated in Scotland by a low barrier in the region of the central part of the Highlands.

In eastern North America similar conditions existed in the Cambrian. The main Appalachian belt was open at the north to receive an Arctic sea and fauna like that now found in northwest Scotland and in the Hecklahook formation in Spitzbergen, part of which Holtedahl (12) considers is equivalent to the Durness limestone (13). Koch and Paulsen (15) have reported from Inglefield Land in northwestern and northeastern Greenland such trilobite forms as *Kootenia,* (*Dorypyge*) and *Wanneria,* and the brachiopods, *Paterina,* (*Qutorgina*), etc., characteristic of the Lower Cambrian of the York and Lancaster Valley, Pa. (16). In the Lower Paleozoic the main Appalachian trough continued northeast across eastern New York, western New England, the St. Lawrence Valley, and the Straits of Belle Isle. Schuchert (17)

reports in the Lower Cambrian rocks of Labrador and western Newfoundland such forms as *Micromitra*, *Kutorgina*, and *Nisusia*, a fauna that is typically developed in the Lower Cambrian of the York and Lancaster Valley and also in the Shady limestone (18) of the Southern Appalachians. Resser (18), in his paper on the generalized Cambrian time scale, discussed these faunas and their routes of migration.

The St. Lawrence seaway, until it was blotted out in the Devonian, lay west of the Green Mountain axis and its continuation in Canada, the Sutton and Notre Dame Mountains. In the basin west of the Green Mountain axis the Central Sequence of Keith (19) contains a Lower Cambrian *Olenellus* fauna the same as that of the Appalachian Valley and western Scotland. The Taconic argillaceous sequence of western New England with the Rysedorph Hill fauna of the Atlantic province of Trenton age, according to Prindle and Knopf (20), probably was deposited east of the Green Mountain axis, and owes its present position on the west side of the Green Mountains to overthrust faulting. The Cambrian found in the Boston Basin, southeastern Nova Scotia and Newfoundland contains the normal fauna of the Baltic facies of the Atlantic Province found in the area south of the Caledonian belt in Great Britain and Sweden.

Fragmentation of Eria.—Such faunal similarities in areas now widely separated by deep ocean basins have led paleontologists to the view that in Paleozoic time a land mass, Eria, extended across the northern Atlantic Ocean and afforded a means of migration for shallow-water faunas. It is known that Scotland in Tertiary time was subjected to block faulting and warping which was accompanied by the great lava flows of that period. At that time the Hebrides were cut off from the mainland by rifting. It has been suggested that this period of block faulting completed the breaking up of Eria (21). In the eastern United States similar block faulting began in early Mesozoic time at the beginning of Triassic and when the movement was completed the coastal areas of New England, Nova Scotia and Newfoundland became table lands cut off by the shore lines. The eastern part of Appalachia which may have extended 100 miles east of the present shore line, also is believed to have foundered into the depths of the Atlantic Ocean during Middle Mesozoic time. The geologic similarities on the two sides of the Atlantic have furnished the greatest support also for the Wegener hypothesis of continental drift. The Wegener hypothesis presents difficulties of acceptance perhaps even greater than that of continental fragmentation and does not come under the scope of the present discussion.

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GEOLOGY.—*Comparison of Cambrian rocks of northwest Scotland with equivalent formations of the Appalachians.*[1] G. W. STOSE, U. S. Geological Survey.

During the field excursion of the Pre-Cambrian Association across the Highlands of Scotland in August 1934, the Cambrian section in northwest Scotland was examined at several places, and the writer noted the close resemblance to formations in the Appalachians with which he is very familiar, having described and mapped them in Pennsylvania, Maryland, and Virginia. The Dalradian series, generally regarded as pre-Cambrian, which lie east of the Moine overthrust, were also examined and the writer suggests their possible equivalence to formations in the Appalachians.

GENERAL GEOLOGY

The Paleozoic rocks of northwest Scotland are exposed in a narrow belt that extends from Durness on the north coast to the east side of the Isle of Skye on the west coast, and lie in a zone between the Torridonian mountains which rise above the Lewisian upland on the west and the great Moine overthrust on the east. Members of the Pre-Cambrian Association saw only the lower part of this section, which comprises quartzites and limestones of Cambrian age, exposed in the vicinity of Loch Assynt and Loch Glencoul. Here the basal Cambrian quartzites rest unconformably on nearly horizontal Torridon sandstone, a late pre-Cambrian red grit and conglomerate closely resembling the Triassic red beds of the Appalachians and little more consolidated than those much younger rocks. These little disturbed red beds lie unconformably on Lewisian gneiss, which is exposed on the lower slopes of the mountains. The Cambrian quartzites dip gently east and form the dip slopes of the east ends of high east-west Torridonian ridges between which are deep narrow valleys, many of them occupied by long picturesque bodies of water or lochs. In the lowland east of these mountains are exposed the upper softer calcareous sandstones and overlying limestones of the Cambrian. In the vicinity of Loch Glencoul the Lewisian gneiss is thrust westward over the Cambrian rocks on the flat Glencoul thrust, a split of the great Moine thrust which lies at a higher level in the mountains to the east. The Cambrian rocks dip gently eastward under the overthrust mass, but the formations are repeated several times in shingle-like imbricate plates or schuppen structure, due to the drag of the

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overthrust mass. The formations examined on the excursion are shown in the chart below. The faunas of the Paleozoic rocks of the Scottish Highlands have been compared with those of the Appalachian section by Grabau, Ulrich, Resser, and others, who recognized their close similarity, but comparison of the lithologic characters of these rocks has not come to my attention.

THE ROCKS

The formations studied on the excursion and those in America with which they are compared are listed in Table 1.

TABLE 1.—Comparison of Strata in Scottish Highlands and Northern Appalachians

Scottish Highlands		Northern Appalachians	
Durness limestone Sailmhor group. Lower part	100′ ±	Middle Cambrian Elbrook limestone	500′
Eilean Dubh group	200′ ±	Lower Cambrian Ledger dolomite	100′
		Kinzers formation (largely shale)	150′
Grudie (Ghrudaidh) group	50′ ±	Vintage dolomite	500′
Serpulite grit Fucoid beds	30′ 50′	Antietam quartzite and Harpers phyllite	1200′
Pipe rock Lower quartzite	500′	Chickies quartzite	1500′
Torridon sandstone Lewisian gneiss		Pre-Cambrian schist	

The quartzites and overlying beds were examined chiefly on the north side of the east end of Loch Assynt. The basal quartzites are cross-bedded and granular and contain coarse grains of glassy quartz and pink feldspar. A few feet of coarser beds or conglomerate are reported at the base, but were not seen by the party. The higher quartzites are massive bedded and contain numerous *Scolithus* tubes and are therefore known as Pipe Rock. Worm tubes of several sizes are described, some large ones are said to be 3 to 4 inches in diameter. The total thickness of the quartzites is about 500 feet. These beds are comparable with the Scolithus-bearing Chickies quartzite in the York-Lancaster region of east-central Pennsylvania, except that in the American section the quartzite is much thicker and therefore

makes higher ridges and the basal beds are generally coarser, in places a cobble bed.

The next overlying formation, Fucoid beds, are described as dolomites, shale, mudstone, and thin beds of dolomite, weathering rusty. What was seen at outcrops is a gray to yellow fine-grained earthy rock with fine black argillaceous streaks, closely resembling the lower part of the Antietam quartzite and the sandy parts of the Harpers phyllite of Pennsylvania and Maryland. Fucoid-like markings on the bedding, whence the name, are now regarded as flattened worm casts. *Salterella* and *Hyolithes* occur throughout this formation and *Olenellus* is reported in the top layers.

The next succeeding formation, Serpulite grit, is an exact duplicate in physical appearance of certain typical quartzite beds of the Antietam of Pennsylvania and Maryland. These characteristic beds include massive white quartzites with slender straight *Scolithus* tubes a yard long; calcareous coarse grit made of round glassy quartz grains, laminated by porous fossiliferous layers, rust-stained on bedding surfaces. These beds contain many *Salterella* hence the name *Serpulite*, and also numerous fragments of *Olenellus*. All these features are duplicated in the Antietam quartzite, one of the key rocks in Lower Cambrian Appalachian stratigraphy and structure. Five species and varieties of *Olenellus* as well as other trilobites, and shells reported from these beds closely resemble, if they are not identical with, forms found in the Lower Cambrian of the Appalachian Valley. The Serpulite grit was seen to grade upward into the overlying dolomite, becoming calcareous at the top and containing rusty fragments of *Olenellus*, just as the Antietam passes into the Vintage or Tomstown dolomite in Pennsylvania.

The next overlying formation, the basal part of the Durness limestone, is called the Grudie (Ghrudaidh) group and is described as a dark, lead-colored mottled dolomite containing numerous *Salterella*. This dolomite seen at a number of places around Inchnadamph and Lake Assynt is a calcareous mud-lump rock and in appearance duplicates the knotty Vintage dolomite of central-eastern Pennsylvania, or the lower part of the Tomstown dolomite of southern Pennsylvania, Maryland, and Virginia. The Grudie is much thinner than the Vintage in America.

The Eilean Dubh group, next in ascending order, is described as a fine-grained white flaggy argillaceous dolomite and limestone. In the area visited we found most of this formation to be a dense massive

light-gray to white pure granular dolomite, weathering creamy, closely similar to the pure massive granular Ledger dolomite extensively quarried in the York-Lancaster Valley of eastern Pennsylvania. The highly fossiliferous Kinzers shale and limestone, which lies between the Vintage and Ledger dolomites in the York-Lancaster Valley, is not represented by similar rock in Scotland. All the rocks above described are of Lower Cambrian age.

Above the pure dolomite beds of the Grudie are thin layers of black oolitic chert, pitted on weathering by dissolved fragments of limestone and possibly of fossils. This is followed by buff siliceous finely wavy laminated calcareous shale or shaly limestone with interbedded thin platy layers of light gray to white fine-grained marble, which is the lower part of the Sailmhor group. This type of limestone was seen by some of the party at only one place, southeast of Inchnadamph, where they pass under a detached remnant of the Glencoul thrust block (klippe) of Torridon sandstone and Cambrian quartzite forming a mountain peak (Beinn nan Cnaimhseag). In lithologic character these beds closely resemble the Elbrook limestone, which also has chert at its base, in southeastern Pennsylvania, and which extends northeastward to the eastern part of the State and southward into Maryland and Virginia. No fossils have been found in these beds in Scotland, but the Elbrook limestone in Pennsylvania contains a scant fauna of Middle Cambrian age.

The upper limestones of the Durness group are not exposed in the area visited because, as previously said, they are cut off by the Glencoul overthrust. As the writer did not see these upper limestones he cannot make a lithologic comparison with the probably equivalent formations in the Appalachians, but fossils reported from them are assigned by Ulrich and others to the "Canadian," or Lower Ordovician, of the Appalachian Valley.

It should be emphasized that the most striking feature about the Cambrian rocks in northwest Scotland, seen by the writer, is their close similarity in lithologic character, sequence, and faunal content with formations of the same age in the Appalachian Valley of eastern Pennsylvania. The only noticeable difference is that their thickness is not so great. It seems reasonable to conclude that all these Cambrian rocks were deposited in a connected basin, probably in the same geosyncline, under very similar climatic and shore conditions, although they are now widely separated by the north Atlantic Ocean.

DALRADIAN SERIES

The Dalradian series, lying east of the Moine thrust in the Southern Highlands, is composed of thick quartzites and boulder beds, limestone, slate, phyllite, and schist that are closely folded and have a very complex structure. Apparently this series was first folded into great recumbent folds or nappes, accompanied by shearing and thrust faulting on their flanks and these flat lying overthrust beds were later closely folded. The Dalradian series is regarded by Professor Bailey, the leader of the excursion, and by some others present on the trip, as pre-Cambrian, which was the reason for their study by the pre-Cambrian Association. We saw the Dalradian series near Ballachulish, on the shores of Loch Leven and of Loch Linnhe, and at Schichallion in the Grampian Mountains. The section as at present established in the Ballachulish and Appin nappes is given below:

BALLACHULISH AND APPINN APPES	SCHICHALLION SECTION
Cuil Bay slates	Loch Tay limestone
Appin limestone	Ben Lui schist
Appin quartzite	Ben Lawers schist
Striped series	Ben Eagach schist
Ballachulish slate	Carn Mairg quartzite
Ballachulish limestone	Killiecrankie schist
Leven schist (phyllite)	Upper Schichallion quartzite
Glencoe quartzite	Tremolite limestone bed
Binnein schist	Lower Schichallion quartzite
Binnein quartzite	Main boulder bed
Eilde schist	Tempar limestone
Eilde flages (Moine)	Banded series
	Gray limestone
	Gray schist
	Tremolite limestone
	Meall Dubh quartzite
	Meall Dubh schist

Professor Bailey in his paper in the Quarterly Journal of the Geological Society of London, 1910, which is accompanied by a geologic map and sections, states that it is not known which is the top or bottom of the section, but he listed the formations in the reverse order from that in the preceding table, Eilde flags at top and Cuil Bay slates at the bottom. In his 1922 paper published in the same journal he stated that he believed the order and sequence published in the earlier report (1910) was correct because it harmonized with his interpretation of the slides as thrusts and with his conclusion that the nappes moved southeastward. In 1924 Vogt presented convincing evidence in the form of current bedding, ripple marks, etc.,

in the quartzites that the section as published by Prof. Bailey was upside down, and in 1930 Professor Bailey in a paper in the same journal accepted this inversion of the section to the order given in the chart above. It is surprising if such a complete change in order of sequence does not make necessary extensive modification of the interpretation of the structure as shown in the published sections and of the conclusions as to the direction of movement. On the excursion, Professor Bailey did not express an opinion as to the direction of movement of the nappes and where the roots of the detached nappes lay. The section in another nappe at Schichallion, now being studied in detail by Professor McCallien of Glasgow University, is given in a parallel column for comparison, but it is not yet correlated with the Ballachulish section.

Only those who have tramped the moors of the Highlands under the adverse conditions of mist and rain can appreciate the labor of the men who have toiled to unravel this complicated geology and the accurate detailed geologic maps they have produced.

A thick series of quartzites and schists at or near the base, 1000 or more feet thick at Schichallion, some quartzites containing pink feldspar grains and some beds at Schichallion containing scattered granite boulders suggesting tillite, impressed the writer in the field as having a Cambrian aspect and the finding of a possible *Scolithus* tube at one place strengthened this impression. The Leven schist, well up in the section near Ballachulish is only a phyllite, much less metamorphosed than the older Bennein and Eilde schists, which is added evidence of the inversion of the column. The black Ballachulish slate, quarried at Ballachulish for roofing purposes, is not so much metamorphosed as the Arvonia slate of Virginia, of Ordovician age. A slaty blue limestone and interbedded carbonaceous slate, called the Ballachulish limestone, impressed the writer as closely resembling the Conestoga limestone of eastern Pennsylvania, also of Ordovician age. Although no fossils have been found in these rocks, the writer ventures to suggest that the Dalradian rocks may be lower Paleozoic formations deposited in a trough southeast of the barrier represented by the overthrust Moine series, and that they may correspond to the Cambrian and Ordovician formations in the Piedmont of the Appalachians, east of the Blue Ridge-Catoctin Mountain barrier.

In the Islands of Islay and Jura, on the southwest coast of Scotland, the belt of Dalradian rocks includes thick quartzites with boulder beds, limestones, slates, and phyllites, similar to the Dalradian at Ballachulish and Schichallion, but the quartzites contain *Scolithus*

tubes, and are called Pipe rock, and other beds, containing worm castings, are called Fucoid beds. They are thus closely similar to the Cambrian rocks of northwest Scotland. Miss Elles, in a paper read at the 1934 meeting of the British Association in Aberdeen, made the statement that she believes these Dalradian rocks on Islay and Jura are Cambrian, and that similar rocks at Schichallion are probably also Cambrian. Peach and Horne, in their posthumous volume on Scotland, 1930, also assign these rocks on Islay and Jura to the Cambrian. At the British Association meeting Doctor Robert Campell also stated that he is of the opinion that beds of the Dalradian series which he has studied northeast of the area seen on the excursion are Paleozoic and he believes that fossils will some day be found to prove it.

GEOLOGY.—*A recent backshore and shoreface terrace along the Severn River, Maryland.*[1] VERNON E. SCHEID, University of Idaho. (Communicated by W. W. RUBEY.)

The ability of unusually large waves to cut a bench and build a terrace in a short time at a higher level than normal was brought to the writer's attention during June, 1934 while at the north shore of Round Bay, Severn River, Maryland. The bay, which is an enlargement of the Severn River seven and one-half miles from its mouth, measures two and one-half miles from northwest to southeast and one and one-half miles from northeast to southwest. The ordinary width of the river is one-half to three-fourths of a mile. Mouthward the river flows southeastwardly in an almost straight line to enter the Chesapeake Bay at Annapolis. The alinement of Round Bay and the lower portion of the Severn River creates a length of fetch of five miles across which the waves may gain in height and energy. The north coast of the bay is at the end of the five-mile fetch and extends in a general east-west direction from Riggs Point to Cedar Point, a distance of slightly less than one mile. Thus when the wind is from the southeast this coast is subjected to the full force of the wave attack.

This section of Maryland is part of Atlantic Coastal Plain and is here underlain by unconsolidated Upper Cretaceous sands and clays with an occasional lens of iron-cemented conglomerate. The shore of the bay is typical of the embayed coastal plain of the Chesapeake Bay region and is the result of shore processes upon a partially submerged youthful topography. The coast line is slightly crescentic and

[1] Received January 16, 1935.

there are hills at and occasionally between the points of the crescents. These same hills have been cliffed by wave action so that the cliff-line[2] presents an undulatory aspect when viewed from the water.

The center of the violent storm of August 21–23, 1933, which damaged the whole eastern seaboard, passed northward over the Chesapeake Bay region. It culminated on the 23rd with southeast gales and exceptionally heavy rain. In twenty-four hours, 7.62 inches of water fell at Baltimore and 5.00 inches at Annapolis.[3] The wind was from the northeast on the 21st and 22nd, but early in the morning of the 23rd it shifted to the southeast and attained a maximum velocity of 50 miles per hour.[3]

The unusually strong winds from the southeast backed up the tidal waters into the many small rivers and inlets of the bay. This action combined with the excessive rains produced very high tides and caused extensive river and lowland floods. For example, in the Baltimore harbor, 16 miles north-northwest of Round Bay, the high tide, which was 7.3 feet[4] above mean high tide, flooded the whole harbor section. Damage from the storm was very heavy. The State Conservation Commissioner, Mr. Swepson Earle, has estimated that about two square miles of coast land was lost in Maryland by wave action. The shift of the wind to the southeast had the same effect at Round Bay as at Baltimore. The southeast-northwest direction of the five-mile fetch allowed the storm waves to reach unusual proportions. Two young men who were at the north shore of Round Bay during the storm informed the writer that there was no exceptional wave activity while the wind was from the northeast, but when the wind veered to the southeast the water level rose approximately six feet and pounded the coast so hard as to destroy a pile-driven pier, several small sheds, and to wrench a one-half horsepower electric water pump from its fastenings and throw it fifteen feet inland and six feet higher. They report that it was during this one day (23rd) that the high-level bench and terrace described below were cut and built.

The profile of the existing backshore (BCDE) and shoreface (EFK) terraces fashioned by normal yearly wave action from the high-level bench (BC) and terrace (CDNPE) produced by the storm of August

[2] Cliff-line: The line of the top of a cliff or series of cliffs, i.e., the line resulting from the intersection of the face of a cliff, or series of cliffs, with the land surface above. Other technical terms follow the usage in Johnson, D. W., *Shore processes and shoreline development*, 1919.

[3] U. S. Dept. Agr. Weather Bur. Climatological Data—Maryland and Delaware Section 38: 29–32. 1933.

[4] Oral communication; Mr. Frank Kipp, Harbor Engineer, Baltimore, Md.

23 is shown in Figure 1. The profile has been made through one of the cliffed hills and shows the present cliff (AB) the top of which is 25 feet above the normal high tide level (EH). It also indicates the changes in the profile of the shore resulting from the wave activity of the storm of August, 1933, and the subsequent normal storms of the winter of 1933–34. BCDE represents the present backshore terrace which varies from zero to six feet wide. It is generally composed

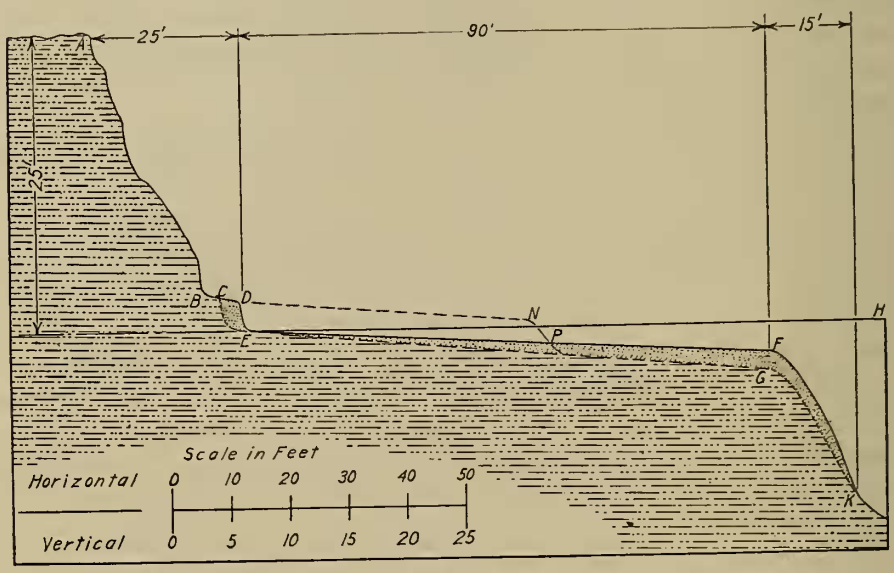

Fig. 1.—Profile of the north shore, Round Bay, Severn River, Md., June 1934.

of two parts; BC, the high-level wave-cut bench now partially covered by cliff debris, and CDE, which is the wave-built portion deposited during the storm. At places either part may form the complete backshore terrace. CE lies beneath CDE and is the basal portion of the pre-storm cliff. The top of the erosion scarp (DE) of the backshore terrace (BCDE) measures two and one-half feet above the present beach created by normal wave activities of the winter of 1933–34. The short-lived high-level terrace that was probably deposited during the storm is indicated as CDNPE. The pre-storm shoreface terrace is shown as EGK while the present shoreface terrace is shown as EFK. The material deposited by wave activity subsequent to the storm is bounded by EFKG and was probably obtained from DNPE, a part of the high-level terrace (CDNPE).

The backshore terrace (BCDE) extends the full distance from Cedar Point to Riggs Point and when seen from a few hundred feet

from shore it has the even appearance of a board walk. The terrace is evidently the result of both cutting and building by the storm waves. The unusually high waves attacked the pre-storm cliffs at the cliffed hills and cut the high-level bench (BC). The material resulting from the cutting of the new bench was immediately deposited on the pre-storm beach or carried along shore by the littoral currents and deposited on the lowland shores. With the subsidence of the storm waters a high-level bench (BC) and terrace (CDNPE) remained on the coast side of the shore. The normal yearly high tides and storm waves of the winter of 1933–34 have cut away much of the high-level terrace (CDNPE) so as to leave the present backshore terrace (BCDE). At some places where the sea cliff is unusually steep and bold no trace of the backshore terrace (BCDE) is seen. This absence may mean that the normal waves of the winter of 1933–34 were able to cut away from the exposed places not only the high-level terrace (CDNPE), but also the bench (BC) that may have been formed during the big storm.

Another effect of the storm observed by the writer was the unusual shallowness of the present shoreface. Formerly, at a distance of 90 feet from the normal high tide shore line (E), the water was four feet deep (G). At present the shoreface at the same spot is only two and one-half feet (F) below normal high tide level (EH). The depth of water at a point 105 feet from the high tide shoreline (E) was formerly and is now 15 feet (K). The new shoreface terrace (EFK) has no doubt been built by normal yearly wave activity. The high-level bench (BC) and terrace (CDNPE) left by the storm of August 23rd was cut into by the waves of the 1933–34 winter and furnished such an excessive load of debris that the waves were not able to remove it completely. This aggraded the former shoreface to form the present shoreface which at point F is two and one-half feet higher than before the storm of August 23rd, 1933.

The above described terrace is certainly not the result of an ordinary large storm unaccompanied by change in the water level. Such a storm would have attacked the pre-storm beach and would have deepened the water. But the severe storm of August, 1933, acted at a high level and probably had very little effect on the pre-storm shoreface and foreshore beach. Instead the waves immediately attacked the pre-storm cliff at a higher level than would ordinarily have been the case. The waves were supplied with an abundance of debris from the cliff so that they built out a small but high-level terrace (CDNPE) upon the surface of the pre-storm beach. The upper surface (CDN)

of the newly built terrace was quickly established as the temporary profile of equilibrium for the storm. With the recession of the storm waters the normal waves began their attack upon the newly established high-level terrace and carried much of the material seaward to aggrade the shoreface as shown in the profile.

GEOLOGY.—*Occurrence of Triassic sediments on the rim of Grand Canyon.*[1] EDWIN D. MCKEE, Park Naturalist, Grand Canyon National Park. (Communicated by JOHN B. REESIDE, JR.)

In 1858, Dr. J. S. Newberry, geologist on Lieutenant Ives' exploring expedition, recognized in the valley of the Little Colorado River where he crossed it about 40 miles below the present town of Winslow a series of rocks which was definitely above and of later age than the highest which he had seen exposed in the walls of Grand Canyon. These rocks, 500 feet thick, were for the most part red sandstones and shales and he referred to them as the "Saliferous series" or "red sandstone series."

During the past sixty years many geologists working in the Grand Canyon region have noted the presence of Newberry's "Saliferous series" in various localities and have contributed to our knowledge of the history and extent of these rocks. Among a large accumulation of data, two things appear to have especial significance. First, since the remnants of these strata are found north, south, east, and west of Grand Canyon and since they are considered on the basis of fossils to have been formed during the Lower Triassic period, it is clearly evident that rocks of this age once covered the entire Grand Canyon area. Second, these remnants furnish evidence that a long period of erosion and wearing away of the region occurred just prior to the beginning of actual Grand Canyon cutting.

South of Grand Canyon isolated remnants of the "Saliferous series" of Newberry, now known as the Moenkopi formation, are found in about nine scattered localities, the farthest southwest of which is in Sycamore Canyon. Both there and in Anderson mesa farther east the exposures are quite extensive laterally and in both cases are protected by lava caps. Since these and the other Moenkopi remnants have considerable bearing on the history of the region, their extent and nature is here summarized:

[1] Published by permission of the Director, National Park Service. Received January 16, 1935.

TABLE 1.—Principal Outcrops of Triassic Rocks South of Grand Canyon

Locality	Thickness	Overlying Beds	Recorder
Sycamore Canyon	300–400′ Moenkopi Cap of Shinarump	Basalt	Robinson (1)
Anderson Mesa N. Side	400′ Moenk. & Shin.	Basalt	Robinson (1)
Anderson Mesa S. Side	550′ Moenk. & Shin.	Basalt	Robinson (1)
Flagstaff	25′–150′ Moenkopi	Basalt	Robinson (1)
San Francisco Peak	? 700′ Moenkopi Shin. & Chinle	Basalt	Gilbert (2)
Cedar Ranch N.E. of Kendrick	280′ Koenkopi 365′ Shin. & Chinle	Basalt	Robinson (1)
Plateau between Diamond and Cataract Creeks	Outlier Moenkopi	None	Newberry (3)
Red Butte 14 mi. S.S.E. Grand Canyon	600′ Moenkopi 210′ Shinarump	Basalt	Ward (4)
Grand Canyon Rowe's Well	50′ Moenkopi	None	McKee
Grand Canyon west of Moran Point	32′ Moenkopi	None	McKee

Near Grand Canyon, outliers of rocks of Triassic age such as Red Butte to the south and Cedar Mesa to the east have long been recognized for what they are. Remnants of such rocks occurring actually on the rim of Grand Canyon, however, have not heretofore been recorded but since the writer has recently discovered their presence there he takes this opportunity of making known the details. Just west of the Hance trail and east of the steep hill formed by the Grandview monocline is one such exposure extending along the rim for approximately half a mile (Fig. 1). It includes the basal conglomerate member, 8 to 20 feet thick, and a maximum of 12 feet of red to yellow, thin-bedded, argillaceous sandstones above. These red sandstones are also to be seen along the Bright Angel fault not far back from the canyon rim on the road to Havasu Canyon (about two miles S.W. of Rowe's Well) but there the underlying conglomerate and the Kaibab formation are not exposed.

One important feature of the discovery of the Moenkopi formation on the rim of Grand Canyon is that it clearly shows that only a very small part of the Kaibab formation has been removed over much of this area by recent erosion. Beneath the Moenkopi is found only a thin exposure of the so-called A-member or Harrisburg gypsiferous

member of the Kaibab. It consists in this locality of two ledges of limestone, each containing abundant casts of Permian pelecypods and gastropods, separated from each other by a red sandstone. This sandstone is seen at Yaki Point and on the Buggeln hill along the Desert View road where it has been mistaken for Moenkopi sandstone because of its color. It is massive, crumbly, and irregularly-bedded, however, so there is no need for confusion if one compares

Fig. 1—Moenkopi basal conglomerate and red sandstone resting on Kaibab formation, rim of Grand Canyon, west of Hance Trail.

lithologic characters. The underlying limestone is the rock that covers a major portion of the plateau surface.

Along the rim of Grand Canyon west of Hance trail the contact between the Moenkopi and Kaibab formations, representing a break between two great eras of geological hitsory, is plainly visible. The subangular pebbles at the base of the former, ranging in diameter up to $2\frac{1}{2}$ inches but averaging about $\frac{1}{2}$ inch, completely cover the flat limestone surface of the latter and in places fill small depressions and channels cut into it. These pebbles are all of the most durable types of rock—jasper, chert, quartz, etc.—varying greatly in color but probably derived mostly from the Kaibab formation and transported only a short distance. A similar bed of conglomerate has been noted at the base of the Moenkopi where the writer has examined it north of Cedar Mesa, along the Little Colorado Canyon, near Cedar Ridge Trading Post, in Sycamore Canyon and in the valley of the Little

Colorado. Robinson (1) records a similar bed, 5 feet thick, at Anderson Mesa to the south while to the north and northwest it has been noted in numerous localities by other geologists so it probably represents a fairly constant unit at the base of the Moenkopi formation.

The discovery of rocks of the Moenkopi formation on the rim of Grand Canyon adds one more geological period to the remarkably great number already known to be represented in this classical cross-section of the history of the earth. Even more than ever before can the Grand Canyon of Arizona be looked upon as a most impressive open book, recording the story of the ages.

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BOTANY.—*Studies in the Gramineae of Brazil.*—I.[1] Agnes Chase, Bureau of Plant Industry.

The grass flora of Brazil is of especial importance to American agrostology. Except for Muhlenberg's *Descriptio Graminum,* published in Philadelphia in 1817, the earliest work on American grasses (which in those days included sedges) was *Agrostografia Brasiliensis* by Giuseppe Raddi, published in 1823. More intensive botanical exploration was carried on in Brazil in the first three decades of the last century than in any other part of America.[2] Many species first described from Brazil are found in the North American tropics, for which reason it is necessary for one studying the grasses of the latter region to have a fairly detailed knowledge of the family as found in Brazil.

Since the early Brazilian collections were but poorly represented in American herbaria, three trips have been made to Brazil for the study and collection of grasses, two by the writer, in 1924–25[3] and in 1929–

[1] Received February 7, 1935.
[2] See Chase, *Identification of Raddi's grasses.*—This Journal **13**: 167–169. 1923.
[3] See Chase, *Eastern Brazil through an agrostologist's spectacles.* Smithsonian Report **1926**: 383–403. 1927.

Fig. 1.—*Lithachne horizontalis* from type. Plant ×½; staminate spikelet, pistillate spikelet with immature fruit, and two views of mature fruit, ×10 dia.

30, and one by Jason R. Swallen in 1933–34. As a result of this work and of helpful cooperation from the Jardim Botanico, and the Museu Nacional, Rio de Janeiro, from the Instituto Biologico, Sao Paulo, and of Professor Bento Pickel, Tapera, Estado de Pernambuco, in addition to numerous collections of Gardner, Glaziou, Salzmann, and many others, the Grass Herbarium in Washington now has the largest collection of Brazilian grasses in the world.

The study of this material has brought to light many species previously known from but a single, often fragmentary, specimen, and also a number of undescribed species. The volume on Gramineae for the *Flora Brasilica*, projected by Dr. Frederico C. Hoehne, chief of the section Botanica e Agronomia of the Instituto Biologico, Sao Paulo, is to be prepared by the writer. It is proposed to publish in this JOURNAL from time to time the new species and notes on some of the little known ones.

Duplicate type material of new species will be deposited in the herbarium of the Jardim Botanico do Rio de Janeiro, and so far as material allows in the herbaria of the Instituto Biologico and of the Museu Nacional. Specimens of species from the state of Minas Geraes will also be deposited in the Escola Superior de Agricultura y Veterinaria, Viçosa, and those from Northern Brazil in the Museu Goeldi, Pará.

Lithachne horizontalis Chase, sp. nov.

Perennis, glabra, caespitosa; culmi steriles 10–30 cm. alti; culmi florentes longe repentes, 30–100 cm. longi, internodiis elongatis; vaginae breves; ligula minuta, fimbriata; laminae planae, oblongo-lanceolatae, 2.5–6.5 cm. longae, 8–13 mm. latae, basi inaequaliter in petiolum brevissimum subito contracta; panicula mascula terminalis, 3–4 cm. longa, 2 cm. lata, spiculis 4–6 mm. longis purpureis; spiculae feminae in nodis culmorum repentium solitariae; gluma secunda et lemma sterile 5–6 mm. longa; lemma fertile 3 mm. longum, 2 mm. latum, 3 mm. crassum, album, maturitate fusco-variegatum, cucullatum, gibbum, apiculatum; palea angusta.

Glabrous perennial in tufts of several erect sterile culms, 10 to 30 cm. tall and 1 to 4 vinelike flowering culms, these 30 to 100 cm. long, running on the ground and rooting at the nodes, simple or sparingly branching, the internodes elongate; sheaths short, slightly auricled; ligule minute, fimbriate; blades horizontally spreading, flat, 2.5 to 6.5 cm. long, 8 to 13 mm. wide, abruptly narrowed at the asymmetric base into a minute petiole hispidulous on the upper surface, the blades scabrous on the margin, especially toward the acute to acuminate apex; staminate panicles 3 to 4 cm. long, about 2 cm. wide, terminal on mostly relatively short culms, the spikelets short pediceled on the subcapillary branches, 4 to 6 mm. long, the lemma and palea purple, acute, the 3 stamens with anthers almost as long as the spikelets, the filaments very short; pistillate spikelets solitary on slender peduncles, borne at the nodes of the long creeping culms, protruding from the side of the sheath or from its summit, rarely one or two borne on the

culms producing the terminal staminate panicles, the glume and sterile lemma equal, 5 to 6 mm. long, acuminate, the glume 5-nerved, the lemma 3-nerved, both with a few obscure cross veins; fruit 3 mm. long. about 2 mm. wide and 3 mm. thick, smooth, dull white, becoming strikingly mottled with grayish brown, the lemma 5-nerved, cucullate, strongly gibbous, abruptly apiculate; palea narrow; rachilla joint remaining attached at base, as a white porcelain-like callus.

Type in the U. S. National Herbarium no. 1,255,920, collected on a moist gentle slope above streamlet, near Bello Horizonte, Minas Geraes, Brazil, March 25, 1925, by Agnes Chase (no. 9057). Known only from the type collection.

Field notes state that the plants were firmly rooted, forming a colony under coarse herbs and *Paspalum paniculatum* L., the long pistillate culms tangled under vegetation, very slender but not readily breaking in untangling; staminate panicles relatively few, the spikelets falling readily; blades flat but curling almost instantly when plants were dug. The colony was found about half a kilometer beyond the end of the Calafate bonde [street car line]. The specific name refers to Bello Horizonte, the beautiful capital of Minas Geraes, and also to the widely creeping pistillate culms.

This third species of *Lithachne* is strikingly different from the two previously known species, *L. pauciflora* (Swartz) Beauv., rather widely distributed in the American tropics, and *L. pineti* (Wright) Chase, known only from Cuba. *Lithachne pineti*, to which it is the more nearly related, is a much smaller, more delicate species, with smaller blades and spikelets, the fruits smaller, the palea pubescent with thick hairs toward the base.

Olyra Sampaiana Hitchc. Journ. Washington Acad. Sci. 17: 215, *f. 1.*—1927.

The type specimen, collected at Reeve, Estado do Espirito Santo, by José Vidal, is almost without underground parts. Specimens collected in 1929 at Alegre, Espirito Santo, about 20 kilometers west of Reeve (*Chase* 10049), show that the roots bear fleshy potato-like bodies, 1 to 2 cm. long and 5 to 8 mm. thick.

BOTANY.—Centrochloa, *a new genus of grasses from Brazil.*[1]

Jason R. Swallen, Bureau of Plant Industry.

Material of a new genus of the tribe Paniceae was collected by the author in the state of Maranhão, Brazil, during a collecting trip in the early part of 1934. It occurs rather commonly on sterile sandy soil in the states of Maranhão and Goyaz in the valley of the Tocantins river, in the region of Carolina. The name of the genus is taken from the Greek κεντρον spur, and χλοα, grass, referring to the pointed callus which extends well below the articulation between the pedicel and the spikelet.

[1] Received for publication February 7, 1935.

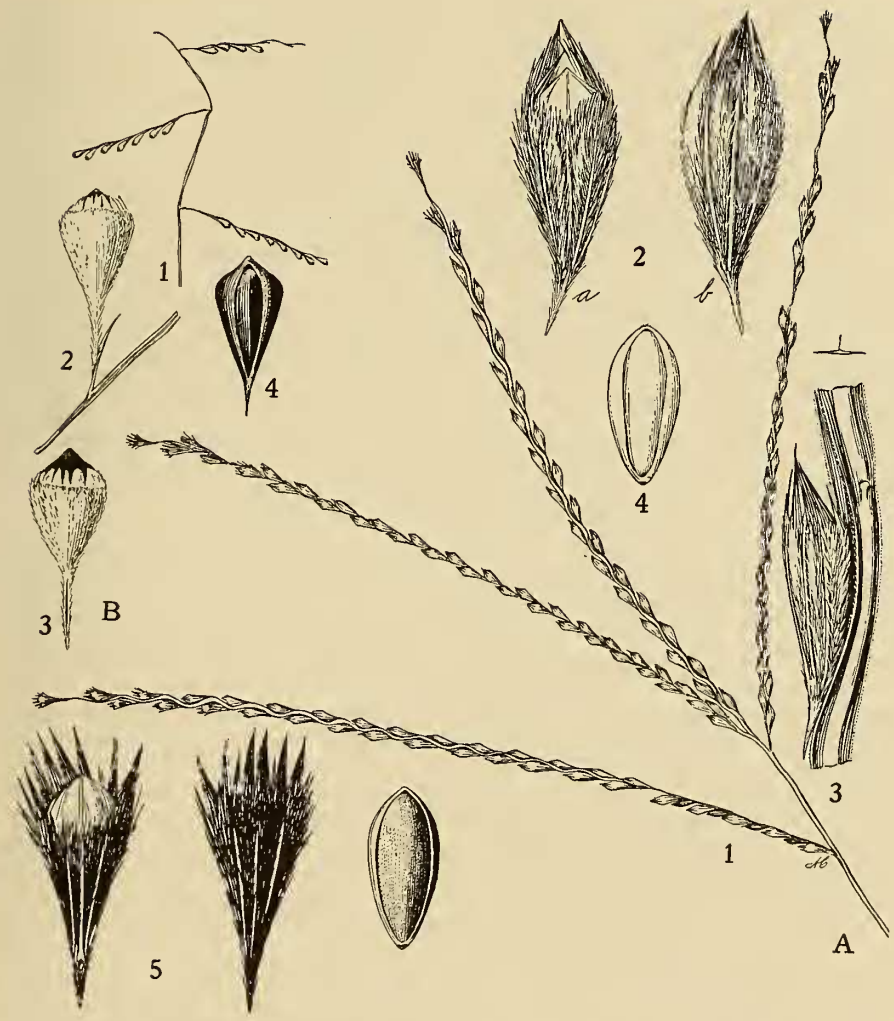

Fig. A.—*Centrochloa singularis*, from type. 1. Panicle, ×1. 2. Two views of spikelet, *a*, from side of sterile lemma, showing the glabrous summit and the scar (at summit of callus) of attachment to pedicel; *b*, from side of second glume, ×10. 3. Three-quarter view of spikelet attached to the narrowly 3-winged rachis, showing the base of callus free from the rachis; pedicel (to right) from which spikelet has fallen; Cross section of rachis (above), ×10. 4. Fruit, ×10. 5. Two views of mature spikelets and fruit, ×10, from *Swallen* 3704.

B.—*Spheneria kegelii*, from *Spruce* 884. 1. Panicle, ×1. 2. Spikelet, from side of sterile lemma, about to fall from the pedicel, showing the oblique articulation from the relatively long pedicel, ×10. 3. Spikelet from the side of second glume showing linear scar of attachment to pedicel, ×10. 4. Fruit, ×10.

Centrochloa Swallen, gen. nov.

Spiculae solitariae, biseriales, breviter pedicellatae pedicellis infra spiculam articulatis, lemmate fertile a rachi averso; callus infra articulum elongatus, arcuatus, acuminatus; gluma prima nulla; gluma secunda subhyalina, cucullata, inter nervos dense hispida; lemma sterile glumae secundae simile, pilis brevioribus; lemma fertile oblongum, marginibus planis.

Gramen annuum, laminis conduplicatis, racemis 2–7 subdigitatis divergentibus.

Spikelets solitary, with the back of the fertile lemma turned away from the rachis, short-pedicellate, readily disarticulating from the pedicel, in two rows on one side of a narrowly winged rachis, the rows separated by a wing on the midrib; callus elongated below the articulation, slender, acuminate, arcuate, pointed; first glume wanting; second glume and sterile lemma equal, thin, prominently 3-nerved, hoodshaped, enclosing the fruit, appressed-hispid between the nerves; fruit indurate, oblong, brown at maturity, minutely striate, the margins of the lemma tightly enclosing the palea, not inrolled.

Annuals with conduplicate blades and two to several sub-digitate, slender, ascending or spreading racemes.

Centrochloa singularis Swallen, sp. nov.

Annua; culmi erecti, 10–75 cm. alti, glabri, ramosi; vaginae compressae, carinatae, glabrae vel margine papilloso-pilosae; ligula truncata, 0.5 mm. longa; laminae conduplicatae, glabrae, 5–15 cm. longae, 3–8 mm. latae, suprema valde reducta; racemi 2–7, 3–14 cm. longi, rachi 0.5 mm. lata, marginibus scabris; spiculae 3.5–4 mm. longae; gluma secunda et lemma sterile 3-nervia, inter nervos dense hispida, pilis glumae secundae quam spiculis longioribus, pilis lemmatos sterilis quam spiculis brevioribus; lemma fertile 2–2.3 mm. longum, viride vel fuscum, apice minute hispidum.

Annual; culms 10–75 cm. tall, mostly single, sometimes 2 or 3, erect, glabrous, branching at all the nodes, the branches enclosed in the sheaths until after maturity of the primary panicle; sheaths compressed-keeled, glabrous or sparsely papillose-pilose on the margins, the lower ones short, overlapping, the two upper elongate but shorter than the internodes; ligule truncate, 0.5 mm. long; blades conduplicate, arcuate, ascending to spreading, glabrous, 5–15 cm. long, 3–8 mm. wide, or smaller in depauperate specimens, the uppermost blade much reduced; racemes 2–7, 3–14 cm. long, the rachis narrowly winged, 0.5 mm. wide, glabrous, the margins scabrous; spikelets obconic, 3.5–4 mm. long, the pedicel very short; second glume and sterile lemma equal, covering the fruit, prominently 3-nerved, appressed-hispid between the nerves, glabrous at the summit, the hairs golden or purple, those on the second glume exceeding the spikelet, those on the sterile lemma shorter than the spikelet, at maturity becoming purplish-black, clustered into stiff points standing away from the spikelet, appearing like a tiny crown; fruit 2–2.3 mm. long, oblong, striate, minutely hispid at the tip, pale green, turning chestnut brown at maturity.

Type in the U. S. National Herbarium no. 1,611,707, collected in open, sandy places between Barra do Corda and Grajahú, Maranhão, Brazil, March 4, 1934, by Jason R. Swallen (no. 3703).

Open sterile sandy land, northeastern Brazil.

Maranhão: Between Barra do Corda and Grajahú, *Swallen* 3703, 3704; between Carolina and Riachão, *Swallen* 4006, 4008, 4021.

GOYAZ: Philadelphia, *Swallen* 3921.

Centrochloa is closely related to the monotypic genus *Spheneria.*[2] These two genera apparently present a case of parallel development, the first from *Axonopus* since the spikelets are placed with the back of the fruit turned away from the rachis, and the second from *Paspalum* since the back of the fruit is turned toward the rachis. In both *Spheneria* and *Centrochloa,* the spikelets readily disarticulate from the pedicel, the articulation in the first being long and oblique and in the second small and round. Furthermore, the spikelets of *Spheneria* are not spurred as are those of *Centrochloa,* and the base of the fruit is long acuminate, while that of *Centrochloa* is blunt as in *Axonopus.*

[2] *Spheneria* Kuhlm. Comm. Linhas Telegraph. Estrat. Matto Grosso **67**: 57. 1922. Based on a single species *S. setifolia* (Doell) Kuhlm.
Spheneria kegelii Pilger, Repert. Sp. Nov. Fedde **26**: 228. 1929. Based on *Paspalum kegelii* C. Muell.
Paspalum kegelii C. Muell. Bot. Zeit. **19**: 324. 1861. "Surinam, in arenosis prope Mariepaston Majo 1846: Kegel (Coll. no. 1316)."
Paspalum setifolium Doell in Mart. Fl. Bras. **2**[2]: 61. 1877. "Habitat in regione Amazonica prope Manaos (Spruce n. 884 et 1360)."
Spheneria setifolia Kuhlm. Comm. Linhas Telegraph. Estrat. Matto Grosso **67**: 57. 1922. Based on *Paspalum setifolium* Doell.

BOTANY.—*New species of the genus* Dimorphandra *Schott section* Pocillum *Tul.*[1]

ADOLPHE DUCKE, Jardim Botanico, Rio de Janeiro. (Communicated by E. P. KILLIP.)

The genus *Dimorphandra* may be divided into two sections: *Eudimorphandra* and *Pocillum,* which are so natural that it would perhaps be better to consider them as subgenera. They are chiefly distinguished by the fruits, and each has a different geographical distribution. The species of *Eudimorphandra* occur throughout the Amazonian hylaea inclusive of Guiana and in tropical Brazil as far south as Rio de Janeiro and the State of S. Paulo. *Pocillum,* however, is strictly limited to the hylaea.

This latter section now contains 15 species, 10 of which are found in the Brazilian states of Pará and Amazonas, and 5 in British Guiana. One of them, *D. macrostachya* of the slopes of Mount Roraima must be included in the flora of both countries, as well as in that of Amazonian Venezuela. Here occurs also the Brazilian *D. pennigera.* The sole species found in French Guiana, *D. polyandra,* is, according to Sandwith, probably an anomalous form of *D. hohenkerkii* of British Guiana. *D. pennigera,* collected in the Brazilian and Venezuelan Upper Rio Negro, must certainly exist in the neighbouring Colombian territories, and *D. gigantea* grows at the frontier of Peru.

[1] Received January 17, 1934.

The habitat of the majority of the species is the upland forest with moist sandy soil, having a surface layer of acid black humus. Here the red-flowered species may be counted among the most elegant and showy trees. Some species, however, are small trees of dry savannas (in Brazil, *campinas*) of white sand. None of them was found in the periodically overflooded Amazonian lowlands.

I have examined herbarium samples of 9 Brazilian and one British Guiana species (*D. congestiflora*, cotype, received from Kew Gardens.) For the four or five remaining species, I am content with the good descriptions in Sandwith's review[2] of the British Guiana *Dimorphandra*. The type specimens of the new species described below are preserved in the Jardim Botanico of Rio de Janeiro; cotypes or duplicates of all species I collected have been distributed to the United States National Museum and to the principal botanical institutions of Europe. Cotypes of *D. gigantea* have been sent to Yale University School of Forestry, accompanied by a wood sample.

KEY TO THE SPECIES OF DIMORPHANDRA SECTION POCILLUM

A—Laminae of the staminodes coherent in the bud, forming a hood-like piece, deciduous at the opening of the flower.

Staminodes anantherous. Flowers relatively large, distinctly pedicellate, white, later becoming yellowish or dirty reddish.

Pinnae 13–21-jugate, leaflets 21–48-jugate. Racemes very long. Amazonian estuary and environs; Rio Trombetas.

D. velutina Ducke.

Pinnae 6–10-jugate, leaflets 20–30-jugate. Racemes shorter. Rio Negro, Cassiquiare and environs of Roraima.

D. pennigera Tul.

Pinnae 1–2-jugate, leaflets 4–8-jugate. Racemes shorter than those of the first species. Manáos.

D. vernicosa Benth

Staminodes with a rudimentary anther. Flowers pedicellate. Pinnae 9–12-jugate; leaflets 20–40-jugate. Not seen. British Guiana.

D. cuprea Sprague & Sandw.

B—Staminodes free.

Staminodes anantherous. Flowers pedicellate, white; petals sericeous-pilose within. Pinnae 2-jugate; leaflets 3–5-jugate, large for this genus. Not seen. British Guiana.

D. davisii Sprague & Sandw.

[2] Kew Bull. Misc. Inf. 1932: 395. 1932.

Staminodes with a rudimentary anther. Petals glabrous within.

Pinnae 1–3-jugate; leaflets 4–7-jugate, fairly large. Flowers pedicellate red. Manáos.

D. ignea sp. nov.

Pinnae 3–5-jugate; leaflets 7–12-jugate, smaller. Flowers pedicellate, red. Plants not seen.

Fertile stamens 5. British Guiana.

D. hohenkerkii Sprague & Sandw.

Fertile stamens 8–10 (perhaps anomalous?). French Guiana.

D. polyandra R. Ben.

Pinnae 3–10-jugate; leaflets 10–33-jugate, small. Flowers sessile.

Leaflets nearly glabrous. Spikes very long and thin; flowers fire-red; calyx distinctly pubescent. Eastern part of the State of Pará.

D. glabrifolia sp. nov.

Lower surface of leaflets sericeous-pubescent. Spikes very long and thin; flowers orange-red; calyx distinctly pubescent. British Guiana.

D. congestiflora Sprague & Sandw

Lower surface of leaflets red brown, ciliolate. Spikes shorter but thicker; flowers of a palish orange color; calyx nearly glabrous. Northwestern part of the State of Pará.

D. campinarum Ducke.

Pinnae 11–17-jugate; leaflets 22–33-jugate, small. Flowers subsessile (pedicel about 0.5 mm. long), red. Manáos.

D. coccinea sp. nov.

Pinnae 13–22-jugate; leaflets 30–54-jugate, very small. Flowers orange-ferruginous, subsessile (pedicel about 0.5 mm.). Indumentum of young branchlets, petioles, peduncles, etc., relatively thin, tomentous. Rio Curicuriary tributary of the Upper Rio Negro.

D. ferruginea sp. nov.

Pinnae 18–17-jugate; leaflets 32–54-jugate, very small. Indumentum of young branchlets, petioles, peduncles, etc., velvet; leaflets nearly glabrous. Tabatinga.

D. gigantea sp. nov.

C—Incompletely known species, of the affinity of *pennigera* according to Bentham. Laminae of the staminodes deciduous, unknown. Pinnae 6–12-jugate; leaflets 17–25-jugate, small. Flowers pedicellate, red (according to Schomburgk). Not seen. Environs of Roraima.

D. macrostachya Benth.

Dimorphandra ignea Ducke, sp. nov.

Arbor 20–35-metralis ramulis foliisque novellis et inflorescentiis tenuiter canoferrugineo-tomentellis. Folia petiolo modice longo, crasso; pinnae 1–3-(saepius 2)-jugae; foliola 4–6-(rarius 7)-juga, brevissime (1–2 mm.) petiolulata, 40–90 mm. longa et 15–45 mm. lata, oblonga vel elliptico-oblonga, basi acuta, apice minime acuminata vel acuta vel obtusa et saepe retusiuscula, coriacea, supra nitida, subtus subopaca et pallidiora, tenuissime penninervia. Racemi 2–7, vulgo 200–300 mm. longi, anthesi plena ad 15 mm. crassi, sat breviter pedunculati, rhachidibus crassis. Flores ignei, numerosissimi, pedicellis 1–1.1/2 mm. longis; calix 1.1/2–2 mm. longus et latus, campanulatus, lobis brevissimis, extus canopuberulus; petala 3–4 mm. longa extus sparsim griseopuberula caeterum glabra; stamina 5, vulgo 4–5.1/2 mm. longa, glabra, petalis longiora; staminodia 5, circa 6 mm. longa, libera, glabra, clavato-spathulata, basi longe stipitata, apice anthera rudimentari coronata; ovarium subsessile dense fulvovillosum. Legumen ut in *D. vernicosa*, sutura superiore fortius bialato-dilatata.

Habitat circa Manáos (civ. Amazonas), sat frequens in silva non inundabili leviter paludosa solo silico-humoso secus rivuli Mindú cursum superiorem et prope cataractam altam fluminis Tarumá ubi 27–5–1932 florifera (leg. A. Ducke, H. J. B. R. no. 23,265).

This new species agrees in the leaves with *D. vernicosa*, but belongs, on account of its flowers, to a very different group of species.

Dimorphandra glabrifolia Ducke, sp. nov.

Dimorphandra macrostachya Ducke, Archiv. Jard. Bot. Rio de Janeiro 4: 39. 1925, non Benth. 1840.

Arbor magna usque 40 m. alta, rarius mediocris. Ramuli novelli, foliorum petioli et rhaches inflorescentiaeque tenuiter cano-vel ferrugineo-tomentosi. Folia vulgo breviter petiolata; pinnae 3–10-jugae; foliola 10–26-juga, sessilia, maiora usque ad 22 mm. longa et 6 mm. lata at saepius 16 mm. longitudine et 4 mm. latitudine non excedentia, apicalia et praesertim basalia gradatim minora, lineari-vel subobovato-lineari-oblonga, basi obliqua apice levissime retusiuscula, margine revoluto, coriacea, supra rugulosa glabra nitida, subtus pallidiora opaca subglabra (pilis minimis sparsis) costa prominente. Spicae 1–6, usque ad 380 mm. longae anthesi plena 10–14 mm. crassae, vulgo breviter pedunculatae, rhachidibus crassis. Flores inodori ignei numerosissimi, sessiles vel subsessiles pedicello 1/2 mm. longo; calix 1–1.1/2 mm. longus, 2–2.1/2 mm. latus, cupularis, breviter dentatus, tenuiter pubescens; petala 3–3.1/2 mm. longa, glabra; stamina 5, glabra, 3.1/2–4.1/2 mm. longa; staminodia 5, libera, 4.1/2–5 mm. longa, glabra, longe stipitata laminis clavato-spathulatis apice anthera rudimentari coronatis; ovarium subsessile dense et longe fulvidovillosum. Legumen forma ut in reliquis hujus sectionis speciebus, usque ad 200 mm. longum et ad 90 mm. latum, adultum glabrum, seminibus 14–18 mm. longis, 8–10 mm. latis crasse albuminosis.

Habitat sat frequens in silva non inundabili at plus minus paludosa solo silico-humoso secus rivulos "nigros," in civitatis Pará parte orientali: prope flumen Aramá in aestuario amazonico, H. J. B. R. no. 20,203 (speciei typus); prope Belem do Pará, Herb. Amaz. Mus. Pará no. 2,149 et 16,846; in insula Collares, H. A. M. P. no. 12,651; prope Sao Caetano de Odivellas ad ostium fluvii Pará, H. J. B. R. no. 11,817; sub radicibus montis Parauaquara inter Prainha et Almeirim, H. J. B. R. no. 10,956. Specimina omnia legit A.

Ducke, exceptis no. 2,149 et 11,817 a M. Guedes et P. Le Cointe lectis. Prope Santa Izabel viae ferreae inter Belem et Bragança, et circa Gurupá visa. In horto botanico Rio de Janeiro culta.

This species was erroneously identified as *D. macrostachya* Benth. by Huber and by myself, according to the original diagnosis where the inflorescences are described as spikes and not as racemes; we have distributed it under this name and I have mentioned it under the same name in various papers. Recently, Sandwith[3] in his most valuable revision of the *Mora* and *Dimorphandra* of British Guiana re-established the true identity of *D. macrostachya* and re-described the type. According to the same author, the Pará species is a very different plant, closely allied to *D. congestiflora* Sprague et Sandw.; this latter, however, has the under surface of the leaflets densely yellowish-sericeous. The leaflets of the numerous specimens of the Pará plant vary considerably in their dimensions, but are constantly glabrous or subglabrous; their lower surface is scarcely paler than the upper, and not sericeous.

Dimorphandra coccinea Ducke, sp. nov.

Arbor mediocris vel magna, ramulis junioribus, foliorum petiolis et rhachidibus inflorescentiisque canotomentellis. Folia petiolo sat longo et robusto; pinnae 12–16 (rarissime 11-vel 17)-jugae; foliola 22–33-juga, sessilia, 7–11 mm. longa et 2–4 mm. lata (basalia et apicalia gradatim breviora), lineari-oblonga, basi obliqua et auriculata, apice retusiuscula, coriacea, supra nitida saepe rugulosa, subtus pallidiora costa prominente et margine revoluto puberula, adulta caeterum subglabra. Spicae 2–7 rarissime 1, vulgo 280–380 mm. longae anthesi plena 12–16 mm. crassae, longiuscule pedunculatae rhachidibus crassis. Flores laete coccinei numerosissimi, subsessiles vel vix ad 1/2 mm. pedicellati; calix circa 1 1/2–2 mm. longus et parum magis latus, cupuliformis lobis brevissimis latis, minime puberulus; petala 3–4 mm. longa extus minime griseopuberula caeterum glabra; stamina 5, glabra, 4–5 mm. longa; staminodia 5, libera, glabra, ad 6 1/2 mm. longa laminis clavato-spathulatis longe stipitatis apice anthera rudimentari coronatis; ovarium subsessile dense et longe fulvidovillosum. Legumina vidi in arbore, forma ut in reliquis hujus sectionis speciebus.

Habitat circa urbem Manáos (civ. Amazonas) sat rara in silva non inundabili solo silico-humoso secus rivulos, locis Cachoeira Grande, Estrada do Tarumá et Colonia dos Francezes, loco ultimo florifera 20-8-1931, legit A. Ducke, H. J. B. R. no. 23,968.

Allied to *D. glabrifolia*, but with very elegant multipinnate and multijugate leaves. The flowering tree is of a remarkable beauty.

Dimorphandra ferruginea Ducke, sp. nov.

Arbor parva vel vix mediocris como ampla umbelliformi, ramulis novellis, foliorum petiolis et rhachibus inflorescentiisque tenuiter et brevissime canoferrugineo-tomentosis. Folia sat longe petiolata; pinnae 13–22-jugae; foliola 30–54-juga, sessilia, maiora usque ad 5 mm. longa et ad 1 mm. lata (basalia et praesertim apicalia minora), lineari-oblonga parum falcata, basi parum obliqua subauriculata, apice subtruncata minime retusiuscula margine revo-

[3] Kew Bull. Misc. Inf. 1932: 395–406. 1932.

luto, coriacea, supra nitida saepe rugulosa glabra, subtus opaca sat dense pilosa costa prominente dense ferrugineovillosa. Racemi 1–5, vulgo 300–400 mm. longi, anthesi plena 12–14 mm. crassi, longiuscule pedunculati rhachidibus crassis. Flores anthesi incipiente dilute aurantiaci demum ferruginei, numerosissimi, pedicellis anthesi circa 1/2 mm. demum 1 mm. longis; calix 1–1.1/2 mm. longus, 2–2.2/3 mm. latus cupuliformis breviter dentatus, extus ferrugineo-puberulus; petala 3–3.1/2 mm. longa, glabra; stamina 5 glabra, 4–5 mm. longa; staminodia 5 libera, ad 6 mm. longa, glabra, laminis clavato-spathulatis longe stipitatis, apice anthera rudimentari coronatis. Ovarium dense et longe fulvovillosum. Legumen ignotum.

Ad ripas saxosas et arenosas fluminis Curicuriary, Rio Negro superioris affluentis (civ. Amazonas), 26-12-1931 flor., leg. A. Ducke, H. J. B. R. no. 23,969.

Allied to *D. campinarum* in the structure and color of the flowers, but differing in the much more numerous pinnae and leaflets.

Dimorphandra gigantea Ducke, sp. nov.

Arbor 50-metralis et forsan altior, trunco basi radicibus tabularibus alte emersis. Ramuli novelli, petioli, pedunculi rhachidesque foliorum et inflorescentiarum pilis densis rufis subvilloso-velutini. Foliorum petiolus sat longus, validus; pinnae 18–27-jugae; foliola 32–50-juga, maiora 7 mm. longa vix ultra 1 mm. lata (basalia et apicalia semper minora), sessilia, linearioblonga leviter falcata, basi truncata parum obliqua subauriculata, apice obtusa vel acutiuscula, margine non revoluto, subcoriacea, supra glabra parum nitida, subtus pallida opaca subglabra costa minime pilosula. Racemi 7–14, in speciminibus nostris juveniles, usque ad 300 mm. longi, longe longe (usque 130 mm.) pedunculati, tenues rachidibus crassis. Flores solum in alabastris novissimis adsunt, subsessiles (anthesi forsan breviter pedicellati), numerosissimi, canopilosuli, petalis nondum e calice exsertis, staminibus fertilibus 5 glabris, staminodiis jam bene evolutis 5 liberis glabris lamina anthera rudimentari coronata, ovario fulvidovilloso. Leguminis valvas putredine plus minus destructas vidi sub arbore, iis speciei *D. velutina* similes.

Habitat in silva non inundabili prope Tabatinga (ad civitatis Amazonas fines occidentales), leg. A. Ducke 28-9-1931 cum ligno no. 22, H. J. B. R. no. 23,789.

One of the tallest trees of the forest near Tabatinga. At first glance it suggests, in its indument and leaves, *D. velutina*, a species with hood-like anantherous coherent staminode-laminae. The proposed species is fairly closely allied to *D. ferruginea*, but is at once distinguished from that species by its size and by the velvety indument of the young branchlets, which form a contrast with the nearly glabrous leaflets. The flowers I have collected, but their color is not apparent.

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Last Winter's Weather.—A survey of the winter of 1934–35 by the U. S. Weather Bureau shows that the season was warmer than usual over almost the entire United States. Between 85 and 90 per cent of the country had super-normal temperatures for the months of December, January and February. Lower-than-average temperatures ruled in a limited area in the Northeast, and along a narrow Atlantic coast strip the records show a just-about-average winter. This warm-winter trend has now lasted for nearly twenty years.

February in particular was warmer and drier than average. This was especially the case in the Northwest. For example, at Bismark, N.D., only one February in the past sixty years has been warmer than the month just closed. Eleven of the past twelve Februaries in that region have been warmer than normal, and the average temperature for all twelve has been ten degress above the normal for the month.

Weather observers in the mountain areas of the West, where summer irrigation must depend on snows of the preceding winter, reported encouraging conditions at the end of winter. In the mountains of the Pacific Coast states especially the snow packs were deep and heavy, and on the whole much greater than last year's; at the same time the water already in the soil was more abundant. Farther east, in the Great Basin and Rocky Mountain regions, soil water was not so nearly up to standard, due to cumulative drought of several years, but the snow supplies on the upper slopes were encouragingly large.

National Bureau of Standards.—New knowledge of propeller vibration and the possible causes of why propellers break in midair is reported by Dr. Walter Ramberg, Paul S. Ballif and Mack J. West. Such propeller failures, while rare compared with the number of propellers in service, usually have serious consequences. Often the flying broken parts rip through the wings of a plane, cause a wreck and sometimes loss of life.

Because it was almost hopeless to try to measure the size of propeller vibrations and the forces in blades while they were whirling rapidly, the government scientists produced a comparable effect by working backward.

Instead of the propeller receiving its vibrations during actual flight the experimental test was performed with a fixed propeller made to undergo the vibrations by having its propeller shaft twisted back and forth mechanically. Thus strains and stresses similar to those encountered during normal operation were set up and could be measured. It was found the vibrations were those of resonance wherein tiny forces, timed at just the right period, built up and amplified one another until the total effect was enough to snap the blade. For the experimental propellers two vibration periods were found; one at the frequency of 35 times a second and the other 130 times a second. For the lower frequency of vibration it was found that the greatest stresses occurred at the middle of the propeller blade.

Smithsonian Institution.—Iroquois murderers were compelled by tribal code to remain on the scene of the crime until discovered, J. N. B. Hewitt of the Bureau of American Ethnology has learned in his studies of the cus-

toms of the Iroquoian tribes. When found by the relatives of the deceased, the criminal might either be killed on the spot, or he might be haled before the tribal council and payment of blood-money be arranged by his relatives. The latter procedure was the one more usually adopted.

Children's Bureau, U. S. Department of Labor.—The large number of deaths of American mothers in childbirth as compared with mothers in other countries cannot be explained away by laying the blame on methods of reporting, it appears from a study conducted by Dr. ELIZABETH C. TANDY.

"The official figure of the United States, which in the last few years has exceeded that of every country except Scotland, remains high no matter what method of assignment is used," Dr. Tandy states.

Differences in methods of assigning causes of deaths are not enough to explain the high maternal mortality rate in the United States, as compared with foreign countries. Even if the method of the country assigning the smallest proportion of deaths to the puerperal state were in use in the United States, the United States figure would still exceed that of all 16 countries included in the study, except Australia, Canada, Chile and Scotland.

Lack of exact knowledge of the antirachitic effect of foods fortified with vitamin D, especially the so-called vitamin-D milk which is now being prepared by three different methods and widely distributed, has made it imperative to work out a method by which the relative merit for infant feeding of these various milks could be determined and comparisons made with standard substances such as cod-liver oil and viosterol containing vitamin D. The children's Bureau through its division of child and maternal health, is now carrying on, in preparation for future studies of vitamin-D milks, a series of clinical tests of the antirachitic value of cod-liver oil and viosterol. These substances are provided for the purpose by the Food and Drug Administration of the Department of Agriculture, which carries out the biological assays for vitamin D. Assistance and advice are being given by the Senior Chemist of the Bureau of Chemistry and Soils of the Department of Agriculture.

NEWS BRIEFS

The recently organized Washington Chapter of the Society for Experimental Biology and Medicine held its first scientific meeting at the Cosmos Club on February 25. The officers of the chapter are: president, Dr. VINCENT DU VIGNEAUD; secretary, Miss SARAH BRANHAM.

PERSONAL ITEMS

Dr. ISAIAH BOWMAN, director of the American Geographical Society, chairman of the National Research Council, and director of the Science Advisory Board, has been elected president of the Johns Hopkins University.

Prof. ROBERT F. GRIGGS of George Washington University lectured on *Dionaea* before the Royal Canadian Institute, Ottawa, on the evening of March 16.

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This JOURNAL, the official organ of the Washington Academy of Sciences, publishes: (1) short original papers, written or communicated by members of the Academy; (2) proceedings and programs of meetings of the Academy and affiliated societies; (3) notes of events connected with the scientific life of Washington. The JOURNAL is issued monthly, on the fifteenth of each month. Volumes correspond to calendar years.

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PHYSICS.—*What is electricity?*[1,2] PAUL R. HEYL, National Bureau of Standards.

I trust that there is no one so optimistic as to suppose that because I have asked this question I am going to answer it, nor so pessimistic as to fear that because I have asked a question which I cannot answer I can offer you nothing but platitudes. I believe it possible in this case to avoid both Scylla and Charybdis.

This question, said the late Professor John Trowbridge[3] of Harvard University, is often asked as though it were capable of a short and lucid answer which might be understood by any person of liberal education. Many answers have been given, but it is interesting to note that the more definite and confident the answer the older it is, and that as we ascend the ladder of time toward the present day such answers as we encounter are less definite and more cautious.

It will be interesting to review, perhaps rather briefly, the ideas which have been held at various times as to the nature of electricity, and then, looking over the wealth of physical discovery which has been amassed in the past forty years, to endeavor to select from it such facts as may be of importance in guiding and controlling future speculation on this question; for though such speculation has been at a minimum, if not a stand-still, during the twentieth century, it will doubtless revive again. Speculation, or as it has been otherwise termed: "apt conjecture, followed by careful verification," has been behind much of the advance of science. Such was the method of Faraday and of Darwin. The conjectures of the ancients, having little in the way of observed fact to guide them, might range far and wide, and had small heuristic value, but with the growth of experiment the range of conjecture has continually narrowed and its value as an aid to further progress has steadily increased.

[1] Publication approved by the Director of the National Bureau of Standards of the U.S. Department of Commerce. Received March 30, 1935.

[2] This is the fifth of the Joseph Henry Lectures of the Philosophical Society presented March 30, 1935, in honor of the first president of the Philosophical Society.

[3] TROWBRIDGE. *What is electricity?* London: Kegan Paul, Trench, Trubner and Co. 1897.

The beginning of our knowledge of electricity is lost in the mists of antiquity. What we can recover of it is excellently told by Park Benjamin in his history: *The intellectual rise in electricity.*[4] It is customary to credit Thales (600 B.C.) with the first observation of the attractive power of rubbed amber, but Benjamin shows that amber was widely known among the ancients for centuries before Thales. Beads of amber have been found in the ancient lake dwellings of Europe, in the royal tombs at Mycenae (2000 B.C.) and throughout northern Italy. The identity in chemical composition of these relics with the amber of the Baltic sea coast is significant of the esteem in which this substance was held and of the distance over which it was thought worth while to bring it. The golden glow of the polished beads suggested the beaming sun, called by Homer ἠλέκτωρ, which doubtless gave rise to the Greek name for amber, ἤλεκτρον.

It is incredible, as Benjamin points out, that this widespread acquaintance of the ancients with amber should have existed so long without its electrical property being often noticed. It is probable that Thales but shared the knowledge of his time in this respect, for his acquaintance with the things of Nature in general was such as to enable him to make the first recorded prediction of an eclipse of the sun. Thales left no writings of his own, and all we know of him we have learned from those who lived several centuries later.

It appears from these authorities that the ancients regarded electricity as a soul or spirit resident in an otherwise lifeless substance. This was in harmony with the prevailing thought of the times, which regarded all motion as evidence of life. The air was inanimate, but the wind was the breath of Aeolus; the waves of the sea were excited by the wrathful strokes of Neptune's trident; the lightning was the thunderbolt of Zeus. This animistic explanation of the nature of electricity was simple and definite enough to be understood by any one, and lasted for several millenniums, in fact until the revival of learning and the growth of experimental science supplied material upon which to base a rival theory.

We are helped to realize this animistic point of view when we read in a translator's footnote to Gilbert's book on *The Magnet*[5] that a certain ancient physician recommended the administration of doses of powdered lodestone in cases of estrangement between husbands and wives. Given the premises of the time, such a conclusion was perfectly logical. It was obvious that the patients exhibited a defi-

[4] London: Longmans, Green and Co. 1895.
[5] Translation by P. Fleury Mottelay. New York: John Wiley and Sons, 1893, p. 56.

ciency of a certain spiritual element which was found in the lodestone, and the administration of that medicine followed as naturally as a modern prescription of cod liver oil because of its vitamin content.

It was the middle of the sixteenth century before the next answer on record was given to the question: *What is electricity?* This answer came from Cardan,[6] whose name is familiar to mathematicians (perhaps more so than it deserves to be). Cardan was the originator of the fluid theory of electricity which held the stage in one form or another for over three centuries, and survives to-day in popular parlance in the term *the electric fluid* or, still more colloquially, *the juice.* Cardan passed from the spiritual to the material in his explanation, which was that amber "has a fatty and glutinous humor which, being emitted, the dry object desiring to absorb it is moved towards its source, like fire to its pasture; and since the amber is strongly rubbed, it draws the more because of its heat."[7]

In this last sentence we see the influence of Cardan's profession. He was, among other things, a physician, and was accustomed to warm the cupping glass in drawing blood from his patients. The laws of pneumatics were not yet understood at that time, and it was generally supposed that the cupping glass acted because of its heat.

The fact that this *fatty and glutinous humor* was intangible and invisible seems to have caused Cardan no embarrassment. We may perhaps view this the more charitably when we think of the contradictory attributes that later scientists have found it convenient to assign to the luminiferous ether.

The year 1551 in which Cardan published this theory may be taken as marking the end of the first era, in which electricity was regarded as a soul or spirit. Its beginning goes back beyond recorded history.

The concept of electricity as a material substance contained in certain bodies known as electrics was strengthened by the experiments of Gilbert (1600), who showed that many substances besides amber were to be included in this class, but the full development of the fluid theory of electricity did not come until the middle of the eighteenth century. In the meantime, von Guericke (1672) had invented his sulphur globe electrical machine, which made electrical experimentation easy on a large scale. With the facilities thus placed at his disposal he discovered electrical conduction and electrostatic repulsion, the latter destined to be a phenomenon of prime importance in later speculation on the nature of electricity.

[6] CARDAN. *De subtilitate*, lib. XXI, Paris. 1551.
[7] PARK BENJAMIN, op. cit. p. 248.

In the eighteenth century development of the fluid theory two names are prominent, those of Du Fay and Franklin, each typifying a separate trend in theory.

Du Fay's experiments (1733 and later) chronologically preceded those of Franklin. His most important discovery was that glass when rubbed behaved in one respect quite differently from amber; a bit of gold leaf excited by contact with the glass tube is then repelled by the glass but attracted by excited amber. "And this," said Du Fay, "leads me to conclude that there are perhaps two different electricities." These he distinguished accordingly as vitreous and resinous, and laid down the law that like electricities repeal each other and unlike attract.

To explain the same phenomenon Franklin (1747) postulated a single electric fluid of which all bodies were normally full. If a body acquired more than this normal amount he called it *plus*, or positively electrified, and if its charge was less than normal, *minus*, or negatively electrified.

Franklin's hypothesis had simplicity in its favor; it required one less assumption than that of Du Fay. In this respect it obeyed more closely the rule laid down by Newton: "We are to admit no more causes of natural things, than such as are both true and sufficient to explain their appearances . . . for Nature is pleas'd with simplicity and affects not the pomp of superfluous causes."[8]

This simplicity of Franklin's hypothesis, added to the reputation which he himself rapidly attained in scientific circles, gave the one-fluid theory an advantage over its competitor for the time being, but a serious theoretical objection was soon raised against it. Since on this theory a negative charge meant a deficiency of electric fluid, there must be a limiting value of negative charge, namely when the body is completely emptied of the electric fluid; but two such bodies, both being negatively charged, should repel each other—and why?

There was much hesitancy on the part of the one-fluid advocates about pushing this argument to its logical conclusion. It remained for a bold German named Aepinus (1759) to seize the bull by the horns and assert that matter devoid of electricity is self-repellent.

This doctrine came as a shock to a generation many of whom could remember Newton. It was useless to point out that Newton had deduced the law of gravitation by observation of bodies that possessed their normal amount of electricity, and that the behavior of matter with the maximum negative charge was something which no

[8] NEWTON. *Principia*, Book III: *Rules of reasoning in philosophy.*

one had ever observed. The one-fluid theory had received a serious jolt from which it never recovered; this argument was used against it as late as the 1830's. The attention of theoretical physicists of the eighteenth century was turned toward the two-fluid theory, and during the closing years of that century and the early part of the nineteenth the work of Coulomb, Laplace, Biot and Poisson produced an elaborate and elegant mathematical theory which so well described all the electrostatic phenomena then known that by 1830 the two-fluid theory was generally accepted.

But it often happens that as soon as one theory is comfortably settled on the throne another rises up to challenge its supremacy. We shall see the reign of each successive theory of electricity growing shorter. The thousands of years of the first era were followed by three centuries of the second. In the first half of the nineteenth century great things were happening. In 1820 Oersted had discovered that an electric current could produce a magnetic effect, thus tying together what had previously been regarded as separate phenomena. In 1822 Seebeck showed that electricity could be generated by heat. These discoveries impressed themselves on the mind of Faraday, then at work in the Royal Institution. He was familiar with the work of Davy in producing chemical decomposition by electricity, and the converse phenomenon of Volta, the production of electricity by chemical action. Faraday was also aware of the converse of Seebeck's discovery, the production of heat (and light) in the electric arc, and his thoughts turned naturally toward the undiscovered converse of the Oersted effect. He says himself at a later time[9] (1845):

"I have long held an opinion, almost amounting to conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin; or, in other words, are so directly related and mutually dependent, that they are convertible, as it were, into one another, and possess equivalents of power in their action. In modern times the proofs of their convertibility have been accumulated to a very considerable extent, and a commencement made of the determination of their equivalent forces."

Such were the considerations which led Faraday to attempt the generation of electricity by means of a magnet (1831). The story is familiar to all of us; how he placed a magnet in a helix of wire and found that no current was produced except momentarily while the magnet was being placed in or taken out of the coil. This discovery seems to have made quite an impression in other than scientific circles, as is evidenced by some verse which has come down to us:

[9] FARADAY. *Experimental researches in electricity*, 3: 1. London, 1855.

"Around the magnet, Faraday
Is sure that Volta's lightnings play.
To bring them out was his desire.
He took a lesson from the heart;
'Tis when we meet, 'tis when we part,
Breaks forth the hid electric fire."

Encouraged by this success, Faraday later (1845) sought and found a correlation between magnetism and light. Twenty years later this in its turn furnished the inspiration for Maxwell's electromagnetic theory, by means of which the domain of optics was annexed to that of electricity.

The publication of Maxwell's paper in 1865 may be considered as closing the second era of electrical theory, that in which electricity was regarded as a material fluid, and the opening of the third era in which the concept of electricity assumed a less material and more elusive form.

By 1865 the two great doctrines of nineteenth century physics, the conservation of energy and the correlation of physical forces (as foreshadowed by Faraday) had been enunciated and were well on the way to general acceptance. During the seventies and early eighties, electricity, in common with heat and light, was sometimes called, in the phrase of the day, *a mode of motion*, which meant a form of energy.

The adoption of this view was, of course, a matter of slow growth. Maxwell's electromagnetic theory had a long struggle for acceptance, so long, in fact, that Maxwell himself did not live to see its final triumph. He died in 1879, and it was not until 1886, when Hertz produced experimentally the electromagnetic waves which Maxwell's theory demanded, that its acceptance may be said to have become complete.

Against this concept of electricity as a *mode of motion*, that is to say, a form of energy, Lodge[10] in 1889 entered a protest. He pointed out that water or air under pressure or in motion represents energy, but that we do not therefore deny them to be forms of matter. He emphasized an important distinction between two terms: *electrification*, which is truly a form of energy, as it can be created and destroyed by an act of work, and *electricity*, of which none is ever created or destroyed, it being simply moved and strained like matter. No one, said Lodge, ever exhibited a trace of positive electricity without there being somewhere in its immediate neighborhood an equal quantity of the negative variety.

[10] LODGE. *Modern views of electricity*, p. 7. London, Macmillan and Co., 1889.

Lodge did much to crystallize the ideas of the time concerning the nature of electricity. These ideas, since Maxwell's merger of optics with electricity, had been, as Lodge pointed out, not clearly defined, but in general the idea was that electricity was in some way a phenomenon of the ether. Lodge enlarged upon this idea, explaining electrostatic phenomena as due to ether stress, electric currents as ether flow and magnetism as ether vortices. Electricity, which had been previously regarded as a material fluid, now became an immaterial one, and in consequence this third period of electrical theory may be called the ethereal era.

As we mount toward the present time we see the different eras of electrical theory rapidly shortening in duration. While the spiritual era lasted several milleniums and the fluid theory three centuries, the ethereal era lasted only a few decades. The fourth era is that which is still with us. It may be called the atomic or quantum period, in which it is noteworthy that but little attention has been paid to the ultimate nature of electricity and a great deal to its structure. It is difficult to say when this period began, as, in fact, the ethereal era began to die almost as soon as it began to live.

Wilhelm Weber,[11] in 1871, in developing his theory of magnetism, pictured to himself light positive charges rotating about heavy negative ones, much like a satellite about a planet; and in 1874 Johnstone Stoney read before Section A of the British Association a paper entitled: *The physical units of nature*, which was not printed until seven years later.[12] In this paper he asserted the atomic nature of electricity and made a rough calculation of the elementary charge on the basis of Faraday's law of electrolysis. Ten years later[13] he was the first to use the term *electron*.

Helmholtz,[14] in his Faraday lecture at the Royal Institution in 1881, further developed this line of thought, saying (p. 290): "Now the most startling result of Faraday's law is perhaps this. If we accept the hypothesis that the elementary substances are composed of atoms, we cannot avoid concluding that electricity also, positive as well as negative, is divided into definite elementary portions, which behave like atoms of electricity."

Maxwell himself saw that his electromagnetic theory was essentially continuous in its nature, and recognized the difficulty arising from the implications of Faraday's experiments. In his *Treatise on*

[11] MILLIKAN. *The Electron* (2nd edition) p. 20. University of Chicago Press. 1924.
[12] STONEY. Phil. Mag. 11: 381–390. 1881.
[13] STONEY. Sci. Trans. Royal Dublin Society, 11th series, IV: 563. 1891.
[14] HELMHOLTZ. Journ. Chem. Soc. (London) 39: 277–304. 1881.

electricity and magnetism (1: 313. Chap. IV. 1873), in the chapter on electrolysis he says: "It is extremely improbable that when we come to understand the true nature of electrolysis we shall retain in any form the theory of molecular charges."

For Helmholtz, however, the atomic nature of electricity was beyond question. Electricity, as he saw it, was a special chemical element[15] whose atoms combine with those of other elements to form ions. Moreover, it appeared to be a monovalent element, for it seemed that a monovalent element combined with one electron, a bivalent one with two, and so on, exactly as a chlorine atom combines with one atom of hydrogen and an oxygen atom with two atoms of hydrogen. Helium, with its zero valence and double electrical charge, was as yet unknown.

The inevitable process of reconciliation of these contradictory theories was early begun by Lorentz,[16] who suggested for this purpose his electron theory of electricity. On this theory all the effects of electricity inside bodies were explained on the assumption of electrons, and all the effects of electricity at a distance, electrostatic, electromagnetic and inductive, required the help of the ether. To unite these two classes of phenomena he assumed that each electron was closely bound up with the ether, and that any change in configuration of the electrons produced a change in the ether which was propagated with the velocity of light, and thus produced action at a distance.

About this time an entirely new line of experimental research was developing which was destined eventually to make the atomic concept of electricity dominant for a time. This was the study of the electric discharge in high vacua. Several workers had investigated this field without attracting much notice, but it remained for Crookes to direct widespread attention to this class of phenomena by an exhibition of novel and beautiful effects in vacuum tubes which he gave at the meeting of the British Association at Sheffield in 1879. Crookes unquestioningly assumed these effects to be due to electrified molecules of residual gas in the tube. It was shown later by others (J. J. Thomson, Townsend, Wilson, Millikan) that the negatively charged particles in a Crookes tube were not molecules or even atoms, but bodies of a minuteness previously unknown, about the 1/1800th part of a hydrogen atom in mass, and bearing a definite negative

[15] GRAETZ. *Recent Developments in Atomic Theory.* London, Methuen and Co. 1923.

[16] LORENTZ. Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen, Amsterdam, 8: 323–327. 1891. Also Archives Neérlandaises, 25: p. 432, Chap. IV. 1892.

charge of electricity. For these tiny bodies the term electron, introduced by Stoney, was revived. Still later work brought to light the proton, with an equivalent positive charge but larger mass than the electron and, in our own day, the positive electron.

As the result of this new line of investigation it became clear that a great many electrical phenomena required the atomic theory of electricity for their explanation. A great many, but not all; for a large number refused to fall in line under a corpuscular explanation, but could be simply and completely explained on Maxwell's theory as ether disturbances. The discovery by Hertz of the electromagnetic waves predicted by Maxwell did much to swing the pendulum back in this direction. The reconciliation of these contending views has been carried on much along the line originally taken by Lorentz. It is of interest to note that his idea of an electron inseparably bound up with the ether is found today in all essentials in the theory of wave mechanics.

We have now brought this somewhat hurried survey of electrical history up to the present day. We have seen that past speculations as to the nature of electricity fall into four classes, each corresponding to an era of thought. In the first of these eras, beginning probably with the earliest observations of electrical attraction, and terminating in the middle of the sixteenth century, electricity was regarded as a soul or spirit. The second era may be said to have been opened by Cardan in 1551 and closed by Maxwell in 1865. During these three centuries electricity was regarded as a material fluid of one or two kinds. It is worthy of note that during this period the concept of the electrical fluid showed a trend toward the immaterial, from Cardan's *fatty and glutinous humor* to the impalpable and imponderable fluid of the early nineteenth century. In the third era electricity in its various manifestations was regarded as some kind of an ether disturbance of a continuous nature. The fourth concept emphasized the atomic or discontinuous structure of electricity without any suggestion as to the ultimate nature of these atoms.

But though speculation as to the ultimate nature of electricity has been in abeyance since the opening of the twentieth century it will certainly arise again, and within limits it is well that it should. We may therefore turn now to an examination of the wealth of material which the last forty years have placed at our disposal and see what it may contain that is likely to be of importance in guiding and suggesting future speculation as to the nature of electricity.

The emphasis laid by the twentieth century on the structure rather

than the nature of electricity is natural, for structure is much more easily determined than nature, and moreover a knowledge of the first is likely to give us some useful hints as to the second. It appears that the discontinuous structure of electricity goes almost hand in hand with that of matter. A tabular view of the known elementary particles of matter with their associated charges of electricity will be useful.

CHARGE	+	−	0
MASS: HEAVY	PROTON	...	NEUTRON
MASS: LIGHT	+ELECTRON	−ELECTRON	(NEUTRINO)

The heavy particles now known, the proton and the neutron, have a mass equal to that of a hydrogen atom; the light particles have about 1/1800 of this mass. The light neutral particle has not yet been discovered, but so urgent is the demand for it in current nuclear theory that it has been named before its advent.

According to the idea that has prevailed for two centuries, positive and negative electricity should be merely reflected images of each other, their properties being equal and opposite. The behavior of the negative electron and the proton shows nothing inconsistent with this concept as far as electrical properties go. On the discovery of the positive electron it was at first thought that it was shorter lived, or as a chemist might say, more reactive than its negative counterpart, but this has not been borne out by subsequent investigation.[17] The mass associated with the positive charge in this case has been investigated by several persons. The latest work is that of E. Rupp[18] who finds that the mass is within five per cent of that of the negative electron. Rupp appears to have found one point of difference between the two which, if confirmed, will be of importance.

It has been found that the passage of negative electrons through thin films of metal is accompanied by a diffraction effect, photographs of the electron beam after transmission showing a series of concentric rings. Rupp passed negative and positive electrons through the same films of gold and aluminum, and found that while the negative particles gave the usual rings the positive particles showed a continuous scattering. We will return to the interpretation of this later.

As to the neutron, it is still uncertain whether it is a proton which has acquired a negative electron or whether it is to be regarded as an independent entity without electric charge. The latter, as we shall

[17] Allowing for relative abundance.

[18] Rupp. Physikal. Zeit. 35: 999. 1934. But in Zeit. f. Physik. 93: 278. 1935, Rupp has withdrawn his earlier article for further verification.

see later, would be in serious conflict with present accepted electrical theory.

There was a time, not so very long ago, when the atom of matter was considered to be its ultimate structural unit. The discovery of the proton and the electron gave meaning to the term *sub-atomic*. With this in mind, the question naturally arises as to a possible further subdivision of the electron. Several observers have claimed to have found evidence of smaller charges than that carried by the electron, but Millikan,[19] after an exhaustive discussion of the subject, came to the conclusion that up to 1924 there had been adduced no satisfactory evidence of this smaller charge.

In the early years of the present century there was some discussion as to whether the electron was to be regarded in shape as a rigid sphere (Abraham) or as contractile. The latter hypothesis was advanced by Lorentz to explain the negative result of the Michelson-Morely experiment. Lorentz supposed the electron, by motion through the ether, to flatten into an oblate spheroid. Experiments by Bucherer[20] in 1909 were interpreted as favoring the hypothesis of Lorentz.

But in 1927 a new line of experimental evidence as to the structure of the electron was opened up by Davisson and Germer,[21] soon followed by G. P. Thomson.[22] These investigators found in brief, that electrons (of the negative variety) might be scattered by reflection or diffracted by passage through very thin films of metal in such a way as to suggest that an electron is at least as much like a little bunch of waves as it is like a particle, and that neither aspect can be ignored.

This is well brought out by G. P. Thomson's diffraction rings. The electron must have a wave aspect, or there would be no interference pattern; it must have a charged particle aspect, or the whole ring system would not be deflected by a magnet, as it is found to be. The whole situation, in fact, had been foreshadowed theoretically by the wave mechanics of de Broglie and Schrödinger.

A number of explanations have been offered for this dual behavior. Perhaps the most completely worked out is that of J. J. Thomson,[23] based upon the diffraction rings obtained by his son, which lend themselves particularly well to theoretical treatment. On this view the electron is associated with and accompanied by a group of waves

[19] *The electron*, Chap. VIII.
[20] BUCHERER. Annalen der Physik **28**: 513; **29**: 1063. 1909.
[21] DAVISSON and GERMER. Phys. Rev. **30**: 705. 1927.
[22] G. P. THOMSON. Proc. Roy. Soc. **117**: 600. 1928.
[23] J. J. THOMSON. *Beyond the electron.* Cambridge University Press. 1928; Phil. Mag. **6**: 1254. 1928.

which guide and direct its motion. Now it was found by a study of the speed of the electrons and the associated wave lengths in the diffraction rings that a curious and complicated relation existed between these quantities. If u is the velocity of an electron and λ its associated wave length, this relation is:

$$\frac{u\lambda}{\sqrt{1-u^2/c^2}} = C \qquad (1)$$

in which c is the velocity of light and C is a constant.

But this, as J. J. Thomson shows, is exactly the relation that should hold for the group speed of electromagnetic waves in a medium such as the Kennelly-Heaviside layer, containing a multitude of electric charges, positive and negative.

J. J. Thomson therefore suggests the following structure for the negative electron:

I. A nucleus which, like the older concept of the electron, is a charge of negative electricity concentrated in a small sphere.

II. This nucleus does not constitute the whole of the electron. Surrounding it there is a structure of much larger dimensions which may be called the sphere of the electron. This sphere contains an equal number of positive and negative charges, forming a little Kennelly-Heaviside layer around the nucleus. Measurements on the diffraction rings indicate a diameter for this sphere at least 10,000 times that previously accepted as the diameter of the electron.

III. The nucleus is the center of a group of waves and moves with the group speed in its atmosphere of electric charges.

At the time that J. J. Thomson proposed this hypothesis the positive electron was not known. Here comes in the importance of Rupp's work[16] previously referred to. On their face, these experiments indicate either that the train of waves that accompanies a negative electron is absent from the positive electron, or that all possible wave lengths are present.

Just as the atom, once regarded as an ultimate structural unit, is now recognized as a complex of electrons, protons, neutrons and possibly neutrinos, so the electron, it seems, must be regarded as a similar complex. Much more, doubtless, is to be learned about its structure before we can hope to answer the question: *What is electricity?*

Perhaps the most outstanding fact in modern physical theory is the dominant position occupied by electricity. In the nineteenth century one spoke of matter and electricity as two separate and in-

dependent entities; nowadays electricity has become the fundamental entity of which matter is merely an aspect. Matter, once supreme, has lost its individuality and has become merely an electrical phenomenon which electricity may exhibit more or less according to circumstances.

It is obvious that our answer to the question: *What is electricity?* will be fundamentally influenced according to whether we hold an electrical theory of matter or a material theory of electricity. It will therefore be worth our while to examine the foundation for the present view that electricity, whatever it may be, is the sole world-stuff. So radical has been this change in our thinking that it would seem a foregone conclusion that it must be based upon the clearest and most unequivocal of experimental evidence.

This change in our concepts did not come suddenly. Its beginning dates back to 1893, when J. J. Thomson[24] showed on theoretical grounds that a charged sphere in motion through the ether would encounter a resistance which to all intents and purposes would appear as an increase in the sphere's inertia, i.e., in its mass. Calculation indicated that this effect would become appreciable only if the velocity of the charged body was comparable to that of light.

In 1893 this suggestion was of academic interest only, no bodies moving with sufficient speed being then available for experiment. A few years later conditions had changed. The study of radioactive substances and of the discharge of electricity through gases had placed at our disposal positively and negatively charged particles moving with unprecedented speeds, which in the case of the negative particles were in some cases comparable with the speed of light. Here, it would seem, was an opportunity to test Thomson's theory of increasing mass.

Unfortunately, the conditions of the problem were such that it was not at first possible to obtain a measure of the mass of such a particle, but only a determination of the ratio of the electric charge to the mass which carried it (e/m).

Kaufmann[25] found, however, that for the swifter particles this ratio was less than for the slower ones. There were only two ways of explaining this fact, both equally radical: either the mass increased or the charge diminished as the speed of the particle became greater.

In this dilemma opinion inclined generally to the first alternative,

[24] J. J. Thomson. *Recent researches in electricity and magnetism*, p. 21. Oxford, Clarendon Press. 1893.

[25] Kaufmann. Gesell. Wiss. Göttingen, Nov. 8, 1901; July 26, 1902; March 7, 1903.

largely because there was in existence a theoretical reason to expect it, while no one as yet had been ingenious enough to suggest any reason why a moving charge should alter. It is of importance to note that Kaufmann's experimental result, because of its equivocal character, cannot be accepted as more than half proving J. J. Thomson's theory.

Kaufman calculated that such particles as he experimented with might have, when moving slowly, an *electrical mass* equal to about one fourth their total mass. In making this calculation he assumed that a particle behaved as though it were a little metallic conductor, but he was careful to point out that a different assumption might lead to another result.

J. J. Thomson, on the assumption that a particle had no metallic conductivity, but acted like a point charge, found that Kaufmann's results indicated that the whole of the mass of the particle might be accounted for electrically.

This was the origin of the electrical theory of matter. Its pedigree goes back to J. J. Thomson's theory, which in turn was derived from the electromagnetic theory of Maxwell. Kaufmann's experiments only half proved Thomson's theory, which in addition was complicated by a special assumption with regard to the distribution of the charge on the particle. Without this assumption only a part of the mass could be accounted for electrically.

But much water has run under the bridge since 1893. Forty years is a long life for any physical theory in these days, and the recent discovery of the neutron has brought with it a challenge to the electrical theory of matter.

In J. J. Thomson's original theory of the increase in mass of a moving charge it was an essential point that the lines of force should be free to adjust themselves as the motion demanded. As a leaf or a card tends to flutter down through the air broadside on, so the lines of force, originally distributed radially and symmetrically about the charge at rest, will tend to set themselves in a plane perpendicular to the direction of motion of the charge. They will not all be able to lie in this plane because of their mutual repulsion, but the density of the lines will be a maximum in this plane and a minimum in the direction of motion, and a certain space distribution will result, of such a nature that the apparent increase of mass can be completely accounted for.

But it is essential for this result that the lines of force shall be perfectly free at their outer ends; in other words, only a single isolated

charge is considered. Now in a structure like the hydrogen atom, composed of a negative and a positive particle, there is bound to be some interference with this freedom of adjustment. In a neutral, non-ionized atom it would appear that all of the lines must begin and end within the atomic structure.

J. J. Thomson must be given credit for foreseeing this difficulty, though the Bohr atom was as yet years in the future. He had an atomic concept of his own in mind at that early date, and pointed out that the distance between the particles constituting an atom must be thousands of times the diameter of a particle. In consequence, he said, almost all of the mass will originate where the lines have their greatest density, near each particle; and the particles are relatively so far from each other that the parts of the lines of force in their immediate neighborhood will have almost perfect freedom of orientation with the motion of the atom.[26]

This is a quantitative question; but it is clear that only under the most favorable conditions will we have a freedom of motion in the atom which approximates that around an isolated charge, and in consequence the electrical explanation of matter, on J. J. Thomson's theory, must be in the same degree approximate.

With the neutron, conditions are more rigid. Assuming the neutron to consist of a proton and a negative electron, the union of these must be almost as close as possible, as the neutron, on modern theory, may form a constituent of an atomic nucleus. Here we are dealing not with atomic magnitudes but with sub-atomic dimensions, which is quite another thing. Freedom of motion of the lines of force in such a structure must be almost non-existent. And if we make the alternative assumption that the neutron is an independent, non-electrical entity, the electrical theory of matter must admit of an important exception.

But an electrical theory of matter to be acceptable must admit of no exceptions. It must obey the *all or none principle*. If it is approximate in even the slightest degree, we are confronted with the existence of two kinds of matter, ordinary and electrical, and we are violating the rule of simplicity in reasoning laid down by Newton.

But has there not been later evidence supporting this theory?

It has sometimes been said that Millikan's oil-drop experiments, by which he measured the charge on a single electron, prove the constancy of this charge, and hence the variability of the mass alone in Kaufmann's experiments. It is true that Millikan found that the charge on an ion *after it had been transferred to the oil-drop* was the

[26] J. J. Thomson. *Electricity and matter*, p. 51. New York: Scribner's. 1904.

same whatever the source of the original charge. Ions of different gases, unquestionably of different speeds, gave the same charge to the drop. But it is to be remembered that the measurement of this charge was made, not at the speed of the ion, but at that of the oil-drop, which was of the order of a few hundredths of a centimeter per second.

The special theory of relativity is sometimes quoted in support of the constant charge and variable mass. It is true that Einstein[27] in his original paper of 1905 gives a formula for the change of mass with the speed of a moving electron, which, like J. J. Thomson's formula, becomes infinite at the speed of light, and that he gives no similar formula for a change in the charge. It will be interesting for us to see how he obtained this result.

In section 10 of his paper Einstein derives the following formula for the x-component of the acceleration of a moving charged particle, together with formulas for the other components:

$$\frac{d^2x}{dt^2} = \frac{e}{m}\frac{1}{\beta^3}X$$

in which e is the charge on the particle, m its rest mass, X the component of the electric vector and β the familiar $1\sqrt{1-v^2/c^2}$.

It is evident that the quantity e/m is altered by the factor $1/\beta^3$, but whether the charge or the mass or both are changed is not obvious. Einstein without comment assumes e to be constant and m to bear the full effect of the modifying factor, and on this basis derives his formula for the change of mass.

This assumption, of course, was orthodox in 1905, but it is of interest to note that as a matter of logic the electrical theory of matter can claim no supporting evidence from the special theory of relativity.

On the basis of this result of Einstein's, Sommerfeld[28] introduced a modification into Bohr's theory of the atom. On Bohr's theory the hydrogen atom was regarded as consisting of a negative electron revolving in a Keplerian ellipse around a positively charged nucleus, the attraction between the two charges being balanced by the centrifugal force of the revolving electron. Sommerfeld (page 45) makes the orthodox assumption that the electrical charges remain constant, but that the mass of the revolving electron varies with its speed according to Einstein's formula. In consequence the mass of the electron fluctuates as it describes its orbit, being greatest at perihelion and least

[27] EINSTEIN. Ann. d. Physik 17: 891. 1905.
[28] SOMMERFELD. Ann. d. Physik 51: 1. 1916.

at aphelion, and its centrifugal force will vary slightly from that in a non-relativistic Keplerian ellipse. Because of this the orbit becomes an ellipse with a moving perihelion, like that of the planet Mercury. The effect of this will be to split up the spectral lines, producing what Sommerfeld called the relativistic fine structure.

This predicted effect has actually been found in the spectra of hydrogen and helium, the number of the component lines and their relative separation being in accordance with theory.

As to the value of this result as a confirmation of the electrical theory of matter, it is to be observed that Sommerfeld would have obtained exactly the same modification of the Keplerian ellipse if he had assumed the charge to decrease and the mass to remain constant, thereby disturbing the balance by reducing the centripetal attraction instead of increasing the centrifugal force.

The logic of the whole situation is that the electrical theory of matter can claim no independent support from Millikan, Einstein or Sommerfeld. It rests for the present on J. J. Thomson's theory, and even this theory assumes tacitly that the charge is unaltered by the motion. It is remarkable that every one we have mentioned, from J. J. Thomson onward, when confronted with the necessity of making a choice, prefers to keep the charge constant and let the mass take the consequences, and this without comment or apology.

Of course, there must be a reason for this; and although it is explicitly stated by no writer that I have seen, the reason is doubtless to be found in a fundamental law of electricity, that of the conservation of electrical charge, with its corollary, the exact equivalence of positive and negative electricity. This law states that no one has ever produced the slightest trace of a positive charge without the simultaneous production of an equal and opposite negative charge somewhere in the neighborhood.

This law has been the subject of some very searching experiments. We may operate within a large conducting cube, such as was built by Faraday at the Royal Institution; perform within it all the usual electrical experiments, excite a glass tube by rubbing it with fur, draw sparks from an electrical machine, and yet a sensitive gold leaf electroscope connected to the cube will remain undisturbed. It seems impossible to create or destroy an electric charge without a compensating creation or destruction of an equivalent charge of the opposite sign.

And yet the era of thought which has not hesitated to question the conservation of energy can hardly be expected to respect this elec-

trical principle; and in fact this law has been brought under fire from several quarters. If these points of order are sustained they will have an important bearing on future answers to the question: *What is electricity?*

It is well to remember in this connection that all the experiments upon which is based the law of conservation of electric charge have started with neutral bodies. The glass tube and the fur were at first neutral, but exhibited equal and opposite charges after being rubbed together; the electrical machine was at first neutral, but on being operated its two sides became equally and oppositely charged.

Suppose a chemist should announce that as a result of the analysis of several thousand neutral salts he had come to the conclusion that acid and basic radicals existed in equal amounts in nature; we would likely think him ignorant of such syntheses as that of the acid radical cyanogen (CN) from its elements in the electric arc. But is there any known electrical analogue of such a synthesis or its reverse dissociation? No, nothing that we have so far been able to produce in the laboratory; yet if we imagine some race of children of the gods who could play with planets as we with pith balls, something of this kind might come to their notice.

Among the phenomena of atmospheric electricity there is an unsolved mystery. Many fruitless attempts have been made to explain it consistently with the principle of conservation of electrical charge. Continual failure has led more than one physicist to look for the explanation in a slight departure from this principle, and it has been shown that a departure so slight as to be beyond laboratory detection would yet, on the large scale, solve this mystery. The difficulty in question is to account for the negative charge of the earth.

Our earth is not a neutral body. Its entire surface is negatively charged to such an amount that there exists near the surface a potential gradient of 150 volts per meter. The conductivity of the atmosphere is small, but not zero; and because of this conductivity and the potential gradient there is a continual conduction of negative electricity away from the earth amounting, over the whole surface of the earth, to a current of about 1000 amperes. Small as this may appear, it is sufficient to bring about a loss of 90 per cent of the earth's charge in ten minutes if there were no means of replenishing the loss. The nature of this replenishment is the mystery referred to.

So great has been the difficulty of accounting for this replenishment that in 1916 G. C. Simpson,[29] now Director of the British

[29] G. C. Simpson. Monthly Weather Review 44: 121. 1916.

Meteorological Office, raised the question of a possible spontaneous production of a negative charge in the earth's interior, but offered no suggestion as to how this could be brought into line with existing theory.

In 1926 Swann,[30] who had worked unsuccessfully with the same problem, followed Simpson's lead, but chose the other alternative of a slight annihilation, or as he called it, death of positive electricity. He was able to bring this into connection with existing electrical theory by generalizing Maxwell's equations. His fundamental idea was that there might be a very slight difference in the properties and behavior of the two electricities. Here again we are reminded of the difference apparently found by Rupp.

Such a suggestion was not without precedent. Lorentz[31] in 1900 had postulated a difference between the attraction of unlike charges and the repulsion of like charges to account for another mystery—gravitation. It must be admitted that the accepted idea of the absolute equivalence and mirror-image character of the two electricities had weakened somewhat when such men as the Director of the British Meteorological Office, the Director of the Bartol Research Foundation and a Nobel prizeman could join in expressing doubt of its accuracy.[32]

Swann's theory of the maintenance of the earth's charge is, from the theoretical point of view, the most successful that has yet been advanced. He modifies the equations of Maxwell by introducing two small terms, amounting respectively to one part in 10^{26} and five parts in 10^{19} of the main term of the classical theory. These additional terms involve the acceleration and time rate of change of positive charge.

Swann assumed no similar terms for the negative charge, his idea being that there is a slight differential effect in behavior. For simplicity, therefore, he introduced a differential term applying only to positive electricity. This assumption enabled him to account for a slow death of positive electricity due to the centripetal acceleration produced by the earth's rotation.

To account for the known electrical facts, there is necessary an annihilation of less than one proton per cc per day, equivalent to a loss of 0.5 per cent of the earth's mass in 10^{20} years. This would also account for as much of the earth's magnetic field as is symmetrical

[30] SWANN. Jour. Frank. Inst. **201**: 143. 1926. Phil. Mag. **3**: 1088. 1927.

[31] LORENTZ. Koninklijke Akademie van Wetenschappen te Amsterdam, Proceedings of the Section of Sciences **2**: 559. 1900.

[32] Additional references: MORE. Phil. Mag. **21**, 196. 1911. GLEICH. Ann. d. Physik **83**: 247. 1927. W. ANDERSON. Ibid. **85**: 404. 1928. A. PRESS. Phil. Mag. **14**: 758. 1932.

about the earth's axis, and would give the correct ratio for the magnetic fields of the earth and the sun. Moreover no development of charge or magnetic field could be detected with a sphere of laboratory size rotating at the highest practicable speed. And finally, Swann's scheme is consistent with the special theory of relativity.

Whatever may be thought of Swann's fundamental assumption, it must be admitted that his theory is experiment-proof. Moreover, even though it should be definitely disproved, it would have the lasting merit of impressing upon us caution in extrapolating laboratory results to the cosmic scale.

The relations of newly discovered fact and existing theory are, as we have seen in this somewhat brief survey, rich in suggestion. Speculation is not dead, but sleeping. If the past is still an indication of the future, it will awake again to renewed activity, and when this occurs we will need a wide acquaintance with fact and a good sense of perspective to guide and direct future speculation on the question: *What is electricity?*

CHEMISTRY.—*3, 4-Dimethoxy-5-chlorocinnamic acid and some of its esters.*[1] RAYMOND M. HANN, Laboratory of J. P. Wetherill, Washington, D. C. (Communicated by GEORGE S. JAMIESON.)

The present communication reports the extension of the study of derivatives of 5-chloroveratric aldehyde (3, 4-dimethoxy-5-chlorobenzaldehyde) to include the synthesis of 3, 4-dimethoxy-5-chlorocinnamic acid. The new acid was prepared by condensation of the aldehyde with malonic acid in the presence of pyridine and piperidine according to the Knoevenagel reaction, the intermediate 3, 4-dimethoxy-5-chlorobenzalmalonic acid losing carbon dioxide during the reaction process to yield the desired substituted cinnamic acid. The acid was characterized by preparation of several of its esters.

EXPERIMENTAL

3, 4-Dimethoxy-5-chlorocinnamic acid.—A solution of 10 grams of 5-chloroveratric aldehyde and 13 g of malonic acid in 10 cc of pyridine was treated with 5 drops of piperidine and heated for one and one-half hours on the steam bath under a reflux, carbon dioxide being copiously evolved. The reaction was completed by refluxing for 15 minutes, the reaction mixture cooled, and treated with 15 cc of concentrated hydrochloric acid in 85 cc of water. The precipitated yellow

[1] Received February 18, 1935.

oil rapidly solidified, and after standing overnight in the ice box it was filtered and dried. Yield 12.0 g, quantitative.

The acid may be recrystallized from water or 50% ethyl alcohol, separating in ball-like clusters of gelatinous needles, but it is preferable to dissolve it in 10 parts of ether, then concentrate to about half volume, when upon standing it separates in colorless glistening prisms melting at 126–7° C (corr.) to a clear oil.

Anal. Calcd. for $C_{11}H_{11}O_4Cl$: C, 54.4; H, 4.6. Neutralization equivalent, 242. Found: C, 54.2; H, 4.7. Neutralization equivalent, 241.

Methyl 3, 4-dimethoxy-5-chlorocinnamate.—One g of 3, 4-dimethoxy-5-chlorocinnamic acid, 10 cc of absolute methyl alcohol and 1 cc of concentrated sulfuric acid were refluxed for four hours, the solution cooled, and the ester precipitated as an oil by addition of 50 cc of water. On standing it crystallized, and upon recrystallization from 10 parts of 80% methyl alcohol was obtained in colorless needles melting at 63° C (corr.). Yield 2.0 g, 95% of theory.

Anal. Calcd. for $C_{12}H_{13}O_4Cl$: Cl, 13.8. Saponification equivalent, 256. Found: Cl, 13.8. Saponification equivalent, 251.

Ethyl 3, 4-dimethoxy-5-chlorocinnamate.—The ethyl ester was obtained by the general procedure used for the methyl homologue. It crystallizes from 50% alcohol in colorless glistening prisms melting at 165° C (corr.) to a clear colorless oil.

Anal. Calcd. for $C_{13}H_{15}O_4Cl$: Cl, 13.1. Saponification equivalent, 271. Found: Cl, 13.0. Saponification equivalent, 265.

Phenacyl 3, 4-dimethoxy-5-chlorocinnamate.—One gram of acid was dissolved in 10 cc of 95% alcohol and titrated with N sodium hydroxide to phenolphthalein alkalinity (4.3 cc), then 0.1 g of acid (to prevent formation of phenacyl alcohol) and 1.0 g of ω-bromo acetophenone in 10 cc 95% alcohol were added and the reaction mixture refluxed for one hour. On cooling the phenacyl ester separated and was recrystallized from 40 cc of 95% alcohol, being obtained in glistening, colorless needles melting at 132° C (corr.).

Anal. Calcd. for $C_{19}H_{17}O_5Cl$: Cl, 9.8. Found: Cl, 10.0.

p-Fluorophenacyl 3, 4-dimethoxy-5-chlorocinnamate.—A solution of the sodium salt of the acid prepared as outlined for the phenacyl ester and 0.7 gram of p-fluoro-ω-chloro acetophenone[2] were refluxed for one hour. The fluorinated phenacyl ester crystallized from alcohol in ball-like clusters of long, colorless needles, and melted at 135° C.

Anal. Calcd. for $C_{19}H_{16}O_5ClF$: Cl, 9.4. Found: Cl, 9.2.

[2] Hann and Wetherill, This JOURNAL, 24: 526. 1934.

p-Chlorophenacyl 3,4-dimethoxy-5-chlorocinnamate.—This ester was prepared by the same general method from p-chloro-ω-bromoacetophenone and crystallized from 40 parts of boiling 95% alcohol in fine, glistening needles melting at 137° C (corr.) to a clear oil.

Anal. Calcd. for $C_{19}H_{16}O_5Cl_2$: Cl, 17.9. Found: Cl, 17.8.

p-Bromophenacyl 3,4-dimethoxy-5-chlorocinnamate.—This ester crystallizes in long, colorless acicular needles melting at 132° C (corr.) to a clear oil.

Anal. Calcd. for $C_{19}H_{16}O_5ClBr$: Saponification equivalent, 439. Found: 437.

SUMMARY

3,4-Dimethoxy-5-chlorocinnamic acid and its methyl, ethyl, phenacyl, p-fluorophenacyl, p-chlorophenacyl, and p-bromophenacyl esters have been synthesized and described.

GEOLOGY.—*Outliers of the Tuscaloosa formation on the western highland rim of Tennessee.*[1] KENDALL E. BORN, Washington University, St. Louis, Mo. (Communicated by ROLAND W. BROWN.)

During the summer of 1933, while mapping the areal geology of Dickson County in the western Highland Rim area of Tennessee, several patches of unrecorded water-worn gravels were noted capping some of the higher hills and interstream areas. These gravels undoubtedly represent remnants of the Tuscaloosa formation of Upper Cretaceous age, which formerly overlay the Highland Rim plateau. The present paper calls attention to these newly recognized occurrences since most of them are farther east than any areas of the formation previously mapped.

The term Tuscaloosa was first applied by Smith and Johnson[2] to the basal Upper Cretaceous deposits in the vicinity of Tuscaloosa, Alabama. In western Alabama and Mississippi the Tuscaloosa, consisting of irregularly bedded clays, sands, and gravels, has an estimated thickness of approximately 1,000 feet. The formation becomes more gravelly toward the north and was formerly considered to thin out in the vicinity of the Alabama-Tennessee line. The presence of this Upper Cretaceous formation on the western Highland Rim was shown by the work of Miser[3] in 1913. Miser determined the age of the

[1] Received January 28, 1935. Published by permission of the State Geologist of Tennessee and the Board of Graduate Studies of Washington University.

[2] SMITH, E. A. and JOHNSON, L. C. *Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers.* U.S. Geol. Survey Bull. 43: 95. 1887.

[3] MISER, H. D. in DRAKE, N. F. *Economic geology of the Waynesboro quadrangle (Tennessee).* Tenn. Geol. Survey, Resources 4: 107. 1914.

gravels exposed in the Waynesboro quadrangle by tracing the overlying red sands (Eutaw formation) into Hardin County where he found a locality showing Cretaceous fossils.

STRATIGRAPHIC RELATIONS

Deposits of Upper Cretaceous age in Tennessee outcrop in a roughly wedge-shaped area which crosses the State in an approximate north-south direction, the greatest areal distribution of the Upper Cretaceous being west of the Tennessee River. This area is about 70 miles wide along the southern boundary of the State, but narrows until at the Kentucky line it is only about 15 miles in width. In the southern counties bordering the Tennessee River the following stratigraphic and lithologic units of the Upper Cretaceous have been recognized:

Ripley formation — Owl Creek tongue; McNairy sand member; Coon Creek tongue

Selma clay

Eutaw formation — Coffee sand member; Tombigbee sand member

Tuscaloosa formation

The Tuscaloosa formation on the western Highland Rim rests unconformably upon Mississippian limestones of Warsaw and St. Louis ages. In the southern counties the Tuscaloosa is overlain by the red micaceous Eutaw sand. In north-central Tennessee the Eutaw is definitely known only as small remnants in Stewart County along the divide between the Tennessee and Cumberland rivers.

LITHOLOGY

The Tuscaloosa formation in Tennessee is represented by well-rounded gravels, consisting essentially of chert with some limestone pebbles. Quartzitic pebbles are not uncommon. In the southwestern corner of the Waynesboro quadrangle Miser[4] noted that the top 30 feet of the Tuscaloosa consisted of "loose gravel, mostly sandstone, quartzite, and quartz in red sand. Quartz pebbles are in greatest abundance." Jewell[5] observed pebbles of quartzite and glassy vein

[4] MISER, H. D. Communication. December, 1934.

[5] JEWELL, W. B. *Geology and mineral resources of Hardin County, Tennessee.* Tenn. Div. of Geol. Bull. 37: 45. 1931.

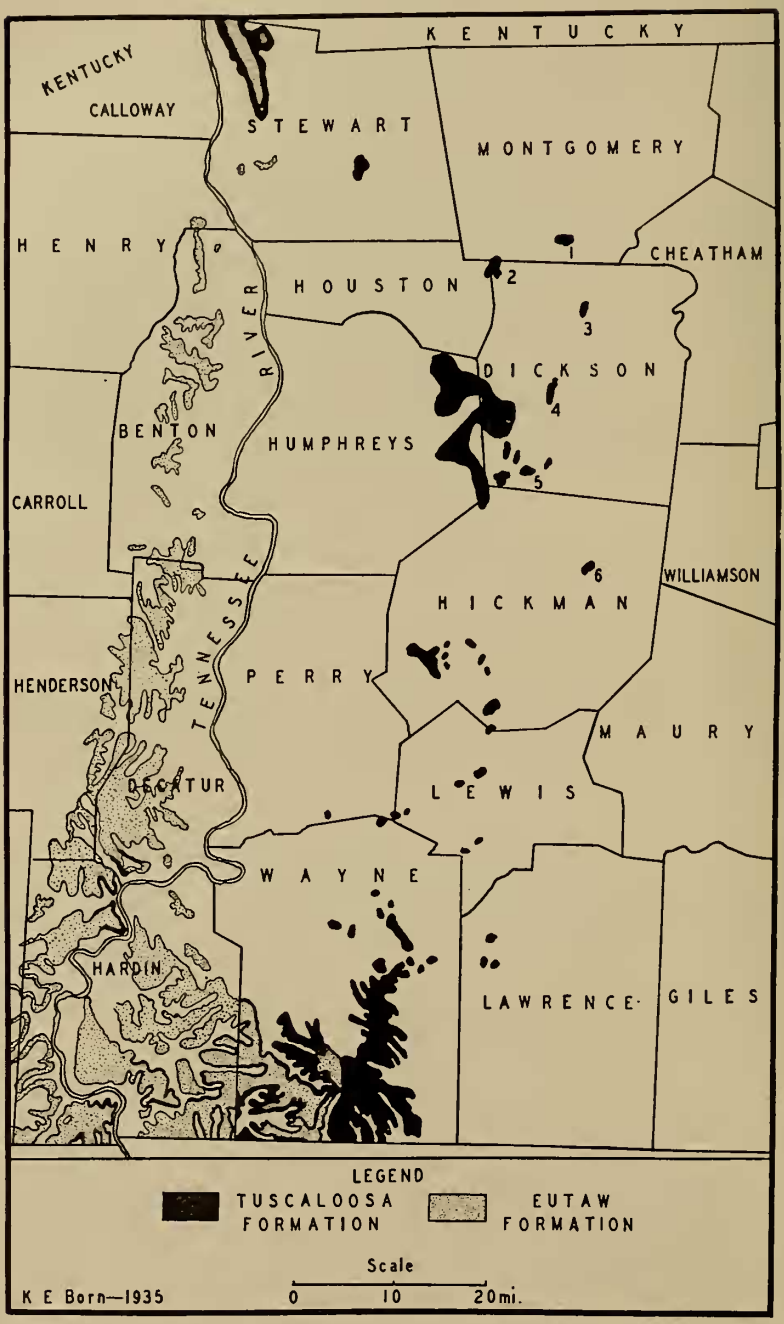

Fig. 1.—Sketch map showing exposures of the Tuscaloosa formation on the western Highland Rim of Tennessee. The numbers indicate new exposures and refer to descriptions in the text. The size of some of the smaller outliers has been exaggerated.

quartz in southeastern Hardin County. These pebbles have apparently had a distinct origin, but their source is speculative. The writer has noted quartzitic pebbles in exposures of the Tuscaloosa gravel on the northern part of the Rim, but always in rather small amounts.

All of the pebbles show definite evidence of water-wear, some of them closely approximating a sphere in shape. A few are polished. The average diameter is between one and two inches, although diameters of 6 to 12 inches have been observed. The color of the pebbles ranges from almost white to a very dark gray, the majority of them being light gray in color.

Locally, the gravels are intimately associated with sands and clays which generally occur as small lenses and pockets. The amount of sand and clay present decreases to the north. For the most part the constituents are poorly sorted although Jewell[6] observed that the lower portion of the Tuscaloosa in Hardin County was coarser than the top.

The matrix of the gravels consists of finely divided calcareous and siliceous material, much of which is clay. In certain localities, especially in the southern counties of the Rim, hydrous iron oxides have cemented the pebbles into a highly indurated conglomerate.

DISTRIBUTION OF THE TUSCALOOSA FORMATION

Miser[7] found that the Tuscaloosa gravels in the Waynesboro quadrangle were 150 feet thick and covered extensive tracts in the southwestern part of that area. In 1914 Wade[8] mapped the Tuscaloosa formation in Tennessee as far north as Perry and northern Lewis counties. Later he[9] traced remnants of the Tuscaloosa as far north as Trigg County, Kentucky. In 1920 Wade[10] gave a summary of his Upper Cretaceous studies in Tennessee in which the distribution and lithology of the Tuscaloosa formation were discussed. More recently Roberts[11] has described the Tuscaloosa and Eutaw formations of western Kentucky.

Formerly, the Tuscaloosa formation was considered to have a very

[6] JEWELL, W. B. Op. cit., p. 45.

[7] MISER, H. D. *Mineral resources of the Waynesboro quadrangle.* Tenn. Geol. Survey Bull. **26**: 25. 1921.

[8] WADE, BRUCE. *Geology of Perry County and vicinity.* Tenn. Geol. Survey, Resources **4**: 173. 1914.

[9] WADE, BRUCE. *The occurrence of the Tuscaloosa formation as far north as Kentucky.* Johns Hopkins Univ. Circ. **3**: 102–106. 1917.

[10] WADE, BRUCE. *Recent studies of the Upper Cretaceous of Tennessee.* Tenn. Geol. Survey Bull. **23**: 51–64. 1920.

[11] ROBERTS, J. K. *The Tuscaloosa formation in Kentucky.* Amer. Jour. Sci. **14**: 465–472. 1927; *Cretaceous deposits of Trigg, Lyon, and Livingston counties, Kentucky.* Kentucky Geol. Survey **31**: 281–326. 1929.

limited areal distribution east of the Tennessee River. However, more detailed studies have revealed isolated exposures of the Upper Cretaceous gravel some 30 to 40 miles east of the river. (See Fig. 1.)

An important link in this chain of outlying areas of gravels of Upper Cretaceous age is the gravels and sands in the vicinity of McEwen and Tennessee City on the central part of the western Highland Rim.

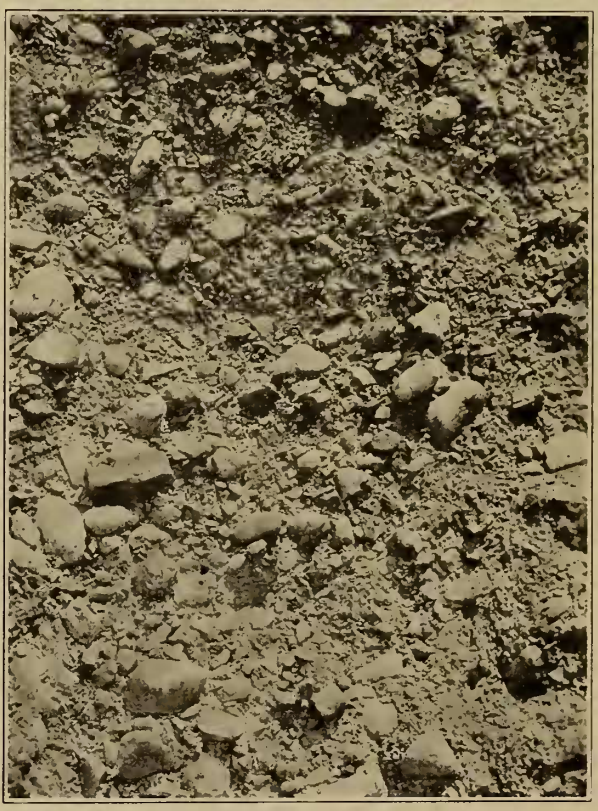

Fig. 2.—Exposure of the Tuscaloosa gravels in a new road cut, about 1½ miles east of Tennessee City. Width of the exposure is about 36 inches.

In this region the Tuscaloosa gravels cover several square miles and have a thickness of more than 25 feet. The gravels are well exposed in most of the new highway cuts between Dickson and McEwen. (See Fig. 2.) Just east of McEwen some 30 feet of the gravels are exposed which are underlain by the highly weathered St. Louis limestone and chert.

In 1930, while working on the brown iron ores of the western High-

land Rim, the writer[12] noted the Tuscaloosa gravels capping the higher hills near Louise in southern Montgomery County (1).* This occurrence of the Upper Cretaceous is some 10 miles farther east than any previously recognized in Tennessee.

During the summer of 1933 several more unmapped outliers of the Tuscaloosa gravels were found in Dickson County. In the extreme northwestern corner of the county, about $4\frac{1}{2}$ miles northwest of Slayden, a small area of Cretaceous gravels occur at an altitude of 650–700 feet. This outlier is more or less continuous into southern Montgomery and eastern Houston counties (2).

About three-fourths of a mile south of Cumberland Furnace, in northern Dickson County, some 25 feet of the Tuscaloosa have been exposed by stream erosion near the crest of a ridge (3). In this exposure the gravels are especially well-rounded, light in color, and have been firmly embedded in sand and clay.

At various places along the north-south ridge bordering the road between Pond and the small village of Hortense, Tuscaloosa gravels were observed (4). Since no bed-rock is exposed in this immediate locality, the thickness of the gravels could not be determined.

South and east of the rather extensive outlier of the Tuscaloosa in western Dickson and eastern Humphreys counties, several small remnants of the Upper Cretaceous gravels were noted forming a veneer on some of the higher hills of the interstream area between Garner Creek and Piney River (5). In these localities, the finer sand and clay have been removed leaving the pebbles scattered as a mantle over the upland and embedded in the residual clays.

During the field season of 1934 a small exposure of gravels, very typical of the Tuscaloosa, was observed just north of the old Johnston iron ore pits, about 4 miles south of Wrigley Furnace in Hickman County (6). This is within 15 miles of the Central or Nashville Basin and is the most easterly occurrence of the formation yet discovered.

ORIGIN OF THE TUSCALOOSA FORMATION

The gravels of the Tuscaloosa formation on the western Highland Rim of Tennessee have been derived from Mississippian limestones and cherts. Mississippian fossils are commonly found in the pebbles. The coral, *Lithostrotion canadense*, indicative of the St. Louis limestone, has been observed towards the center of several pebbles.

[12] BORN, K. E. *The brown iron ores of the western Highland Rim of Tennessee.* Jour. Tenn. Acad. Sci. 7: 22. 1932.

* The numbers in parentheses refer to numbers of localities on the map, Fig. 1.

Berry,[13] basing his conclusions on certain resemblances to present deltas, believes that the Tuscaloosa formation in Alabama represents a series of Cretaceous deltas. This interpretation may be correct for Alabama, where the amount of sand and clay is greater and where paleobotanical evidence is present, but in Tennessee, and especially the northern part of the Highland Rim region, the clays and sands become much less abundant and the Tuscaloosa consists of gravel with only subordinate amounts of sand and clay. Roberts[14] noted this same constitution of the Tuscaloosa in Kentucky and he suggested a marine origin of the gravels. Field observations by the writer point toward a similar origin for the Tuscaloosa formation on the western Highland Rim of Tennessee. The Tuscaloosa gravels in this region are believed to be shore gravels deposited through overlap by the advancing Upper Cretaceous sea.

During the late Carboniferous and early and middle Mesozoic time the western Highland Rim is believed to have been a land mass. During this long geologic interval the land suffered erosion and Wade[15] suggested that the general area was a low-lying land. Wells[16] believes the region was reduced to a peneplain. In western Kentucky Sutton[17] has pictured the topography at the beginning of Tuscaloosa time as an irregular land surface in a mature stage of development. In the southwestern part of the western Highland Rim, Miser[18] interpreted the pre-Tuscaloosa topography as an uneven surface on which sink holes and underground channels were common.

As the result of downwarping, the Upper Cretaceous was initiated in the Embayment region by a transgressing sea which rounded the Mississippian limestones and cherts. The eastern limit of the Tuscaloosa sea in Tennessee is not definitely known, but the present recognized distribution of these basal gravels indicates that the sea encroached far upon the western flank of the Nashville arch.

The size and degree of rounding displayed by many of the pebbles appear to warrant a marine rather than a deltaic origin for the Tusca-

[13] Berry, E. W. *The delta character of the Tuscaloosa formation.* Johns Hopkins Univ. Circ. **3**: 18–24. 1917; *Upper Cretaceous floras of the eastern Gulf region in Tennessee, Mississippi, Alabama, and Georgia.* U.S. Geol. Survey Prof. Paper **112**: 26–30. 1919.

[14] Roberts, J. K. *The Tuscaloosa formation in Kentucky.* Amer. Jour. Sci. **14**: 470–472. 1927.

[15] Wade, Bruce. *Geology of Perry County and vicinity.* Tenn. Geol. Survey, Resources **4**: 176. 1914.

[16] Wells, F. G. *Ground water resources of western Tennessee.* U.S. Geol. Survey Water-Supply Paper **656**: 22–23. 1933.

[17] Sutton, A. H. *A pre-Cretaceous soil horizon in western Kentucky.* Amer. Jour. Sci. **22**: 450–451. 1931.

[18] Miser, H. D. *Mineral resources of the Waynesboro quadrangle.* Tenn. Geol. Survey Bull. **26**: 58–59. 1921.

loosa gravels on the western Highland Rim. Although our present knowledge of the Upper Cretaceous geography of this area is meager, it is believed, as suggested above, that the western Highland Rim was then a region of little or moderate relief. Considerable relief must be assumed to account for cobbles, many of which are 5 and 8 inches in diameter, to be washed into deltas. At present we have no basis for the assumption of any great amount of relief during the early Upper Cretaceous in west-middle Tennessee. No large pebbles are known in the present day stream gravels and it is probable that the present relief of the Rim region is greater than that of Cretaceous time. It appears, therefore, more likely that this rounding of Mississippian limestones and cherts has resulted from wave and tidal action of a sea transgressing a deeply weathered land area.

The width of the Tuscaloosa belt in Tennessee is also suggestive of a marine origin for the gravels. Very extensive deltas would be necessary to account for the rather wide distribution of the Tuscaloosa as indicated by the chain of outliers already known, and further detailed study of additional areas on the western Rim will probably reveal other outliers of the Tuscaloosa formation.

In the southern counties of the Rim and in the area west of the Tennessee River, the Tuscaloosa is overlain conformably by the Eutaw sand whose origin is certainly marine. In Hardin County, Jewell[19] has noted sands, similar to those in the Tuscaloosa, intercalated with the gravels and finer sands of the Eutaw formation. Continuous deposition is strongly suggested.

The presence of the Eutaw in Stewart County and in western Kentucky strongly suggests that these sands were deposited by the Upper Cretaceous sea when depth became favorable for the deposition of finer sediments. It is probable that the Selma and Ripley, and perhaps even younger formations, were laid down over a portion of the western Highland Rim.

Since the Tuscaloosa gravels form a basal conglomerate of a transgressing sea, the formation becomes progressively younger from south to north. The gravels in Dickson and Stewart counties are undoubtedly younger than any part of the gravels in northwestern Alabama and northeastern Mississippi. The Eutaw outliers in Stewart County and western Kentucky may be as young as basal Ripley.

The withdrawal of the Cretaceous sea from the Embayment area again subjected the Highland Rim to erosion and during the peneplanation of the late Cretaceous and early Tertiary most of the de-

[19] JEWELL, W. B. Personal communication. August, 1934.

posits of Upper Cretaceous age were removed. The existing patches of the Tuscaloosa and Eutaw in this region represent remnants of these formations which were probably continuous at one time over most or all of the present western Highland Rim.

BOTANY.—*A new species of* Dracaena *from the Department of Petén, Guatemala.*[1] C. L. Lundell, University of Michigan. (Communicated by H. H. Bartlett.)

While collecting in the savanna country of the Department of Petén, Guatemala, in 1933, I discovered a grove of very interesting monocotyledonous trees in Monte Hiltun, a strip of forest separating Sabana Hiltun and Sabana Zotz. The trees were not in flower or fruit so that only sterile material was obtained. The species is apparently referable to the genus *Dracaena*.

Dracaena petenensis, sp. nov.

Arbor solida 6 usque ad 12 m. alta. Caulis 20–30 cm., basi expansa 70–90 cm., diam. Cortex tenuis fissuris irregularibus aliquantulum angustatisque et fastigiis paucis, inaequalibus, acutis, humilibus, griseus fusco-maculatus sub folia circulis griseis, fuscis vel rubris irregulariter circumdatus. Rami pauci, crassi, 15 cm. sub apice 10–15 mm. diam. Folia ramorum apice congesta, pendula, minutissime, serrulata glabri, griseo-viridia, 115–140 cm. longa, 18–20 mm. lata, basta dilata, amplexicaulia, integra scariosa, laminis linearibus, supra basin angustatis apice in aciem late setiformem coarctatis.

Type in the herbarium of the University of Michigan, *C. L. Lundell 3271*, collected in Monte Hiltun, Department of Petén, Guatemala, May 17, 1933. Cotype deposited in the United States National Herbarium, Washington, D. C.

The characters which distinguish *Dracaena petenensis* are (1) the massive trunk with expanded base, (2) the few, thick branches, and (3) the crowded, pendent, minutely serrulate, linear leaves 115 to 140 cm. long and 18 to 20 mm. wide. The other New World representative of the genus, *Dracaena americana* Donn. Smith, is occasionally encountered in the same region. It is a smaller tree with entire leaves 20 to 30 cm. in length.

[1] Received February 7, 1935. Papers from the Department of Botany and the Herbarium of the University of Michigan, No. 527.

ZOOLOGY.—*The histology of nemic esophagi.* IV. *The esophagus of* Metastrongylus elongatus.[1] B. G. Chitwood, Bureau of Animal Industry and M. B. Chitwood.

This is the fourth paper of a series[2] dealing with the structure of the

[1] Received November 18, 1934.
[2] Chitwood, B. G., and Chitwood, M. B. *The histology of nemic esophagi.* I.

esophagi in various groups of nematodes. In this paper, insofar as possible, the same nomenclature for the various nuclei and cells will be used as in the previous papers.

GROSS MORPHOLOGY

The esophagus of *Metastrongylus elongatus* is clavate and may show grossly 3 indistinct regions, an anterior moderately narrow part or corpus, a very slightly narrower part, or isthmus, and a posterior wide part or bulbar region. The length of the esophagi in specimens studied varies from 262μ to 616μ; however, in the description a single specimen with an esophagus 450μ long has been used, since relative positions and lengths are fairly constant. In this specimen the corpus is approximately 162μ long, the isthmus 90μ long, and the bulbar region 198μ long. The dorsal esophageal gland opens into the lumen at the anterior end of the esophagus, while the subventral glands open into the lumen 126μ from the anterior end or 36μ from the posterior end of the corpus. The lumen is triradiate throughout the length of the esophagus; in the anterior part of the corpus the ends of the radii are very slightly rounded (Fig. 1b) and the cuticle is thickened.

NUCLEAR DISTRIBUTION

The corpus may be subdivided into 2 regions, a precorpus and a postcorpus, on the basis of nuclear distribution, these regions approximating the parts of the corpus of *Rhabditis*.

Precorpus. In the anterior part of the corpus, 22 nuclei, comprising 6 radials (r_{1-6}) and 16 nerve cells (n_{1-16}) have been constantly observed. In addition to these there are 4 questionable bodies (s_{1-4}), possibly nuclei of nerve cells, and 1 nerve cell nucleus (n_{8x}) which sometimes appears to be distinct and sometimes identical with n_8. The radial nuclei (r_{1-6}) are arranged in a single group of 6, 1 nucleus on each side of each sector 9 to 18μ from the anterior end of the precorpus.

The nerve cell nucleus n_1 is situated slightly to the right of the mediodorsal position, 7μ from the anterior end of the precorpus; n_{2-3} are situated near the center of the subventral sectors at the same level as n_1; n_{4-6} are situated about 15μ from the anterior end, near the center of each sector; n_7 is about 9μ from the anterior end of the precorpus and in the center of the dorsal sector, while n_{8-9} are near the same level as n_7, 1 nucleus in the center of each subventral sector; n_{10} is immediately posterior to n_9, while n_{8x} is immediately posterior to n_8 or possibly identical with n_8; n_{11-13} are approximately 38μ from the anterior end of the precorpus, 1 nucleus near

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The esophagus of Rhabdias eustreptos (*MacCallum*, 1921). Zeit. f. Zellf. u. Micro. Anat. **22**: 29–37. 1934.

Ibid. II. *The esophagus of* Heterakis gallinae. Zeit. f. Zellf. u. Micro. Anat. **22**: 38–46. 1934.

Ibid. III. *The esophagus of* Oesophogostomum dentatum. This JOURNAL **24**: 557–562. 1934.

the center of each sector; and, finally, n_{14-16} are about 45μ from the anterior end.

The bodies s_{1-4} are near the external surface of the esophagus, s_{1-2} being about 18μ from the anterior end of the precorpus, 1 nucleus near the center of each subventral sector, while s_{3-4} are about 26μ from the anterior end of the precorpus and arranged similar to s_{1-2}.

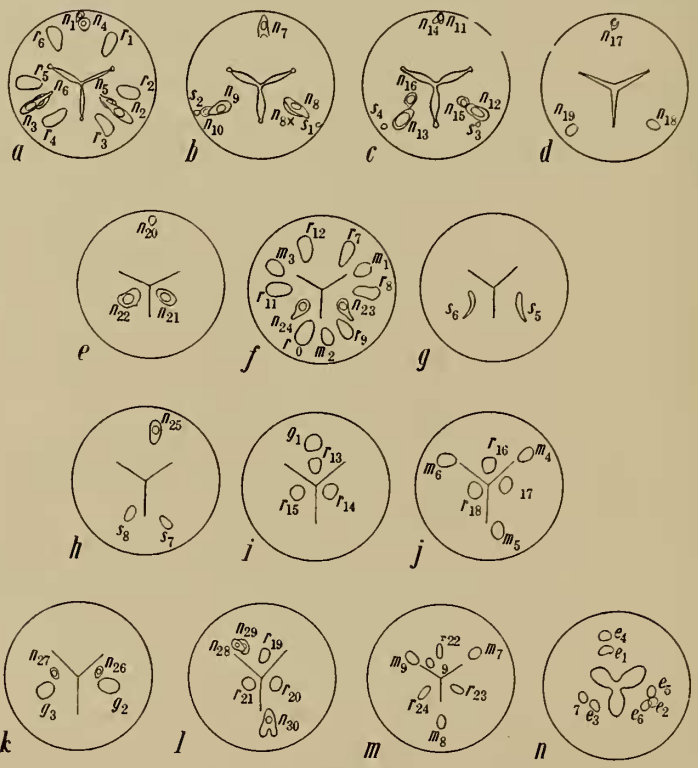


Fig. 1.—Nuclei of esophagus, diagrammatic representation. *r*, *m*, *s*, *g*, *n*, various types of nuclei; *a–c*, nuclei of precorpus; *d–h*, nuclei of postcorpus; *i–j*, nuclei of prevalvar region; *k–m*, nuclei of postvalvar region; *n*, nuclei of esophago-intestinal valve.

Postcorpus. The postcorpus contains 22 nuclei comprising 6 radial nuclei (r_{7-12}), 3 marginal nuclei (m_{1-3}), 9 nerve cell nuclei (n_{17-25}), and 4 nuclei (s_{5-8}), possibly those of nerve cells. The marginal nuclei (m_{1-3}) are arranged as a group of 3, 1 nucleus at the end of each esophageal radius, about 72 to 80μ from the anterior end of the esophagus or about 18 to 26μ from the anterior end of the postcorpus. The radial nuclei (r_{7-12}) are arranged similar to the radials (r_{1-6}) of the precorpus and are about 6 to 12μ posterior to the marginal nuclei.

The nerve cell nuclei consist of 2 groups of 3 nuclei (n_{17-19} and $_{20-22}$), 1 nucleus near the center of each sector, the first group situated approxi-

mately at the anterior end of the postcorpus, and the second group about 6 to 10μ posterior to the first group; a pair of subventral nerve cell nuclei (n_{23-24}) situated about 18 to 25μ from the anterior end of the postcorpus; and a single dorsal nerve cell nucleus (n_{25}) posterior to the orifices of the subventral glands, about 134μ from the anterior end of the corpus or 28μ from the posterior end of the corpus.

In addition to the above, there are 4 nuclei (s_{5-8}) which appear similar to those of nerve cells, but no cell body was observed. The first pair (s_{5-6}) is situated 6 to 10μ posterior to the radials r_{7-12}, 1 nucleus in each subventral sector, while the second pair (r_{7-8}) is near the posterior end of the postcorpus, about 6μ posterior to the last dorsal nerve cell (n_{25}).

Isthmus. As indicated by the distribution of nuclei, the isthmus is a region 90μ long between the corpus and the anterior part of the bulbar region, and contains no nuclei.

Prevalvar region. The anterior part of the bulbar region, the prevalvar region, contains 10 nuclei comprising 6 radial nuclei (r_{13-18}), 3 marginal nuclei (m_{4-6}), and 1 gland cell nucleus (g_1). The radial nuclei are arranged in 2 groups of 3 nuclei each, 1 nucleus of each group near the center of each sector; the first group (r_{13-15}) is about 6 to 12μ from the anterior end of the prevalvar region, while the second group (r_{16-18}) is situated 138 to 150μ from the anterior end of the region. The marginal nuclei (m_{4-6}) are arranged like those of the first group (m_{1-3}), and are situated at about the same level as the second group of radials (r_{16-18}) of this region.

The dorsal esophageal gland nucleus (g_1) is about half way between the 2 radial groups (r_{13-15} and $_{16-18}$) of this region. However, g_1 is quite variable in position, and in other specimens it may be situated further posterior, even at the level of the subventral gland nuclei.

Postvalvar region. The postvalvar region of the esophagus usually contains 16 nuclei as follows: 6 radials (r_{19-24}), 3 marginals (m_{7-9}), 2 gland cell nuclei (g_{2-3}), and 5 nerve cell nuclei (n_{26-30}). In addition to these, 1 more nucleus (s_9), possibly that of a nerve cell, has sometimes been observed. The radial nuclei are arranged in 2 groups of 3 nuclei each, 1 nucleus near the center of each sector; the first group (r_{19-21}) is situated 18 to 24μ from the anterior end of the postvalvar region, while the second group (r_{22-24}) is situated at the posterior end of the esophagus. The marginal nuclei (m_{7-9}) are arranged like the other margins (m_{1-3} and $_{4-6}$), and situated 6 to 10μ from the posterior end of the esophagus.

The subventral esophageal gland nuclei (g_{2-3}) are in the center of their respective sectors, at the anterior end of the postvalvar region in the particular specimen described here. Sometimes, however, these nuclei are situated in the prevalvar region, 6 to 10μ anterior to the last group of radials of that region (r_{16-18}).

The subventral nerve cell nuclei (n_{26-27}) are symmetrically placed, 1 nucleus near the center of each subventral sector, situated at approximately

the anterior end of the postvalvar region; the dorsal nerve cell nuclei (n_{28-29}) are situated just anterior to m_9, with 1 nucleus (n_{28}) anterior to the other (n_{29}); the ventral nerve cell nucleus (n_{30}) is a little to the left of the ventral esophageal radius, 6 to 12μ anterior to m_8. In addition to these nuclei, a right subdorsal nucleus (s_9) was observed in 1 series of sections; it appeared similar to the nucleus of a nerve cell but no cell body was observed.

Esophago-intestinal valve.—The esophago-intestinal valve consists of 2 parts, an anterior part with a trilobed lumen the wall of which contains 3 nuclei, 1 nucleus near the center of each lobe, and a posterior part with a rounded lumen the wall of which contains 4 nuclei, of which 1 nucleus is dorsal, 2 left subventral, and 1 right subventral.

CHARACTER OF NUCLEI

The radial nuclei each contain a moderate sized nucleolus lying in a finely granular, very delicately basophilic nucleoplasm. In cross section the radial nuclei of the corpus (r_{1-12}) are elongated, 7.9μ long by 3.7 to 4μ wide, their long axes corresponding to the radius of the esophagus; those of the prevalvar region (r_{13-18}) are subtriangular, 6.2 to 7μ long by 5 to 5.8μ wide, while those of the postvalvar region (r_{19-24}) are ellipsoidal, 6.2 to 7μ long by 2.9 to 3.3μ wide.

The marginal nuclei are similar to the radial nuclei except that the nucleolus is slightly larger in proportion to the nucleus, and sometimes a second, smaller nucleolus is present. All of the marginal nuclei are ellipsoidal to slightly subtriangular. The nuclei of the first group (m_{1-3}) are about 3.4μ long by 3.3μ wide, those of the second group (m_{4-6}), 7.9μ long by 5μ wide, and those of the third group (m_{7-9}), 4.5μ long by 2.5μ wide.

The gland cell nuclei are the largest nuclei of the esophagus, the dorsal (g_1) 6.2μ long by 6.2μ wide, and the subventrals (g_{2-3}) 7μ long by 8.7μ wide. Each of these nuclei contains a proportionally large nucleolus in a very homogenous, basophilic nucleoplasm.

The nerve cells consist of several types, the nuclei varying greatly in size and character. A brief description of these nuclei may be clarified through reference to figure 4. The dorsal nerve cell nuclei of the corpus are of 3 types, as follows: n_1 is of a type containing a nucleolus in a nucleoplasm which shows no affinity for stain; $n_{4,7,17,}$ and $_{25}$ are of a type containing a bilobed, irregular nucleolus, or 2 nucleoli in a nucleoplasm basophilic at the margin; $n_{11,14,}$ and $_{20}$ are of a type containing a deeply basophilic nucleoplasm without distinct nucleolus. Of these, n_{25} appears to be a cell of the commissure at the base of the postcorpus, the cell body being large and the cytoplasm homogenous and eosinophilic; n_4 and $_7$ have similar cytoplasm or cell bodies, but are apparently bipolar; the remaining cells have a very small cell body and are spindle shaped and bipolar.

The subventral nerve cells of the corpus contain 2 types of nuclei, $n_{2-3,5-6,}$ $_{15-16,23-24}$ having a nucleoplasm basophilic at the margin, while $n_{8-9,10,12-13,}$

18–19,21–22 contain a few basophilic granules but the nucleoplasm is not basophilic at the margin. All of the subventral nerve cell nuclei contain a bilobed nucleus or 2 separate nucleoli; the cells appear to be bipolar and the

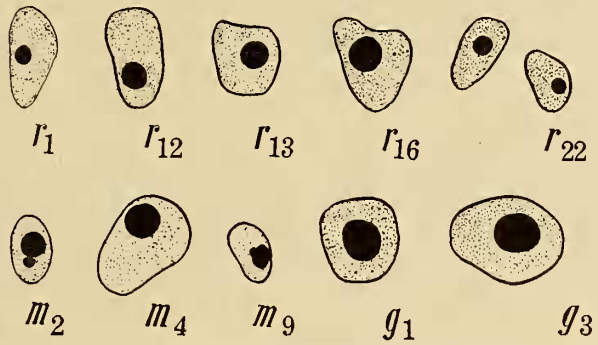


Fig. 2.—Individual nuclei of esophagus. Labelled as in fig. 1.

Fig. 3.—Nerve cells of esophagus. Labelled as in fig. 1.

cell bodies homogenous and basophilic, but the size and shape varies with the individuals cell (Fig. 4).

The bodies of the corpus labelled *s* are not all of the same character. Those labelled s_{1-4}, possibly nerve cells, are strongly basophilic and somewhat similar to n_{11}, but no cell bodies were observed (the writers are not entirely

certain that they are nuclei); s_{5-6} are obvious nuclei with lobed nucleoli and clear nucleoplasm, 1 body lying near the inner ventral side of the anterior part of each subventral gland and surrounded by deeply staining cytoplasm, but no cell wall observed; s_{7-8} are similar nuclei situated ventral and medial to the subventral glands. Nuclei in similar positions and of similar character are present in other nematodes, but a comparison of these nuclei will not be taken up until later.

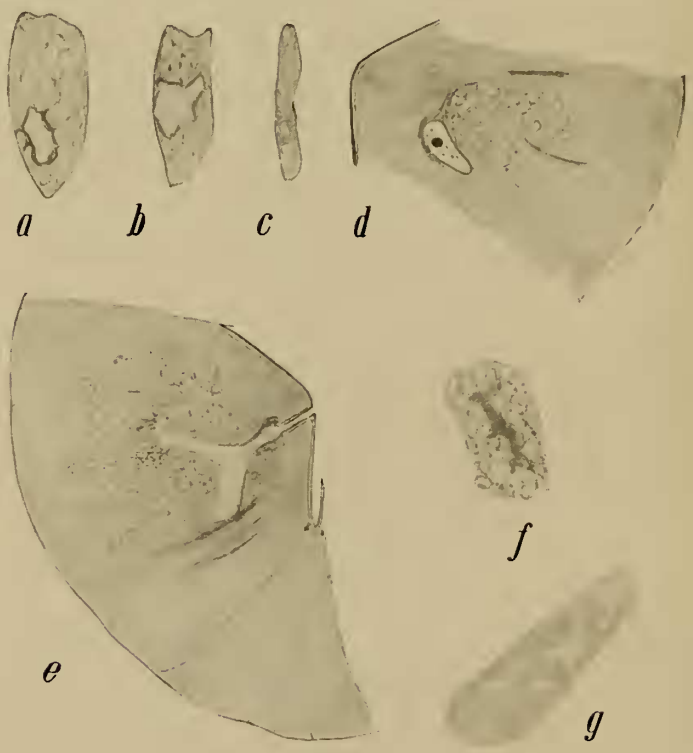


Fig. 4.—Esophageal gland mass as seen in cross section. *a*, dorsal gland near orifice; *b*, dorsal gland immediately posterior to *a*; *c*, dorsal gland at level of m_{1-1}; *d*, subventral gland anterior to orifice; *e*, subventral gland at level of orifice; *f*, subventral gland in section immediately posterior to *e*; *g*, subventral gland in anterior part of bulbar region.

The nerve cell nuclei (n_{26-30}) of the bulbar region are, in general, larger nuclei than those of the corpus (Fig. 3); all contain a lobed nucleolus in a clear nucleoplasm having a few basophilic granules. The cell bodies are large, the cytoplasm lightly eosinophilic and sometimes vesicular (see n_{30} of Fig. 4). All of these cells appear to be commissural cells; they have 2 chief processes which come off at the same side of the cell body and then diverge. The single *s* nucleus (s_9) of the bulbar region appears to be similar to the nuclei of the nerve cells of the same region but no cell body has been observed.

ESOPHAGEAL GLANDS

The dorsal esophageal gland has a very short narrow duct lined with cuticle which is continuous with a protoplasmic central tubule having a thick deeply basophilic wall. This tubule becomes wider and bifurcates posterior to the orifice of the gland, each branch giving off numerous short branches which are continuous with the coarsely reticulate, deeply basophilic cytoplasm of the gland (Fig. 4a–b). In the anterior part of the precorpus the dorsal gland is rather wide and circumscribed, and occupies a central position in the dorsal sector. In the remainder of the corpus the dorsal gland is narrow (Fig. 4c) and the gland mass finely reticular to alveolate; it becomes a narrow strand in the region of the isthmus, and again larger in the anterior part of the bulbar region. Near the level of its nucleus, the dorsal gland becomes multilobed and occupies a large part of the dorsal sector; in this region the cytoplasm is dense and contains a few alveoli.

The subventral glands extend some distance anterior to their orifices; in this region the cytoplasm is very finely reticulate (Fig. 4d). Near the level of their orifices the subventral glands become multilobed but the finely reticular structure remains. Each gland has an extremely short duct lined with cuticle, and continuous with this duct is a thick-walled protoplasmic tube which is immediately multibranched, the branches continuous with the reticulum. Posterior to this region the gland mass, like the dorsal gland, becomes smaller until it is finally reduced to a delicate strand of protoplasm in the isthmian region. The subventral glands become enlarged in the posterior part of the prevalvar region, become lobed in the region of their nuclei, and then continue to be large and lobed nearly to the base of the esophagus. The protoplasm is dense throughout this region except in the part adjacent to the lumen. In general, the mass of the subventral glands is less basophilic than that of the dorsal, and sometimes appears to be very slightly eosinophilic.

ZOOLOGY.—*Development and morphology of the cestode,* Hymenolepis cantaniana, *in coleopteran and avian hosts.*[1] M. F. JONES and J. E. ALICATA, Bureau of Animal Industry. (Communicated by ELOISE B. CRAM).

Previous to the preliminary note by Alicata and Jones[2] in 1933, the life history of the poultry cestode, *Hymenolepis cantaniana,* was unknown. There was reported at that time the finding, in the dung beetle *Ataenius cognatus,* of proliferating larvae which consisted of a mycelium-like structure, numerous buds, and partially or completely de-

[1] Received March 12, 1935.

[2] ALICATA, J. E., and JONES, M. F. *The dung beetle,* Ataenius cognatus, *as the intermediate host of* Hymenolepis cantaniana. Jour. Parasitol. 20: 244. 1933.

veloped cysticercoids (Fig. 1). The larvae developed to maturity in chicks and were identified as *H. cantaniana*. The present paper gives a more detailed account of the development and morphology of the proliferating larva of this cestode in the intermediate host, *Ataenius cognatus*. Since the previous report, 2 additional beetles, *Ataenius stercorator* from Puerto Rico and *Choeridium histeroides* of local origin have been found to harbor similar proliferating larvae, presumably those of *H. cantaniana*. The larvae from *Ataenius stercorator* were collected by Dr. H. L. Van Volkenberg and sent to the Zoological Division for identification, with the statement in a personal communication that this material was identical with that which he reported, but

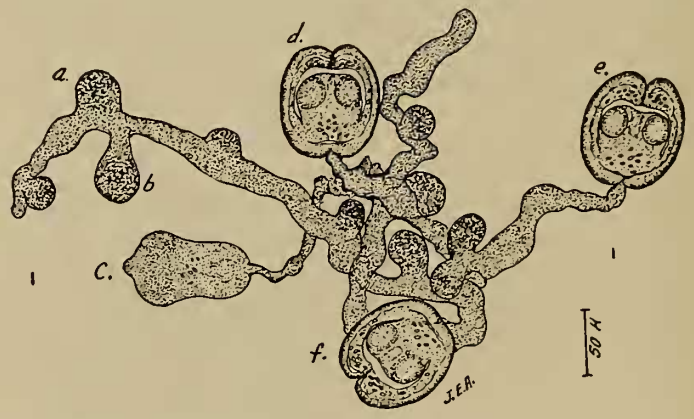


Fig. 1.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus*. Natural infestation. *a*, *b*, *c*, developing cysticercoids; *d*, *e*. *f*, apparently mature cysticercoids still attached to branching larval tissue. After Alicata and Jones, 1933.

did not describe in 1931.[3] In the present paper, geographical distribution and seasonal occurrence of the intermediate hosts are discussed briefly. A short description of the adult worm, with data regarding its development, subsequent to laboratory feedings, in the chicken, guinea fowl, and bobwhite quail, also are included.

The authors wish to thank Dr. E. A. Chapin of the U. S. National Museum for identifying beetles and for supplying data regarding distribution of the 3 beetles reported as intermediate hosts.

SOURCE OF LARVAL MATERIAL

The greater part of the cestode larvae available for study occurred as natural infestations in numerous specimens of *Ataenius cognatus;* larvae were observed also in one specimen of *Choeridium histeroides.*

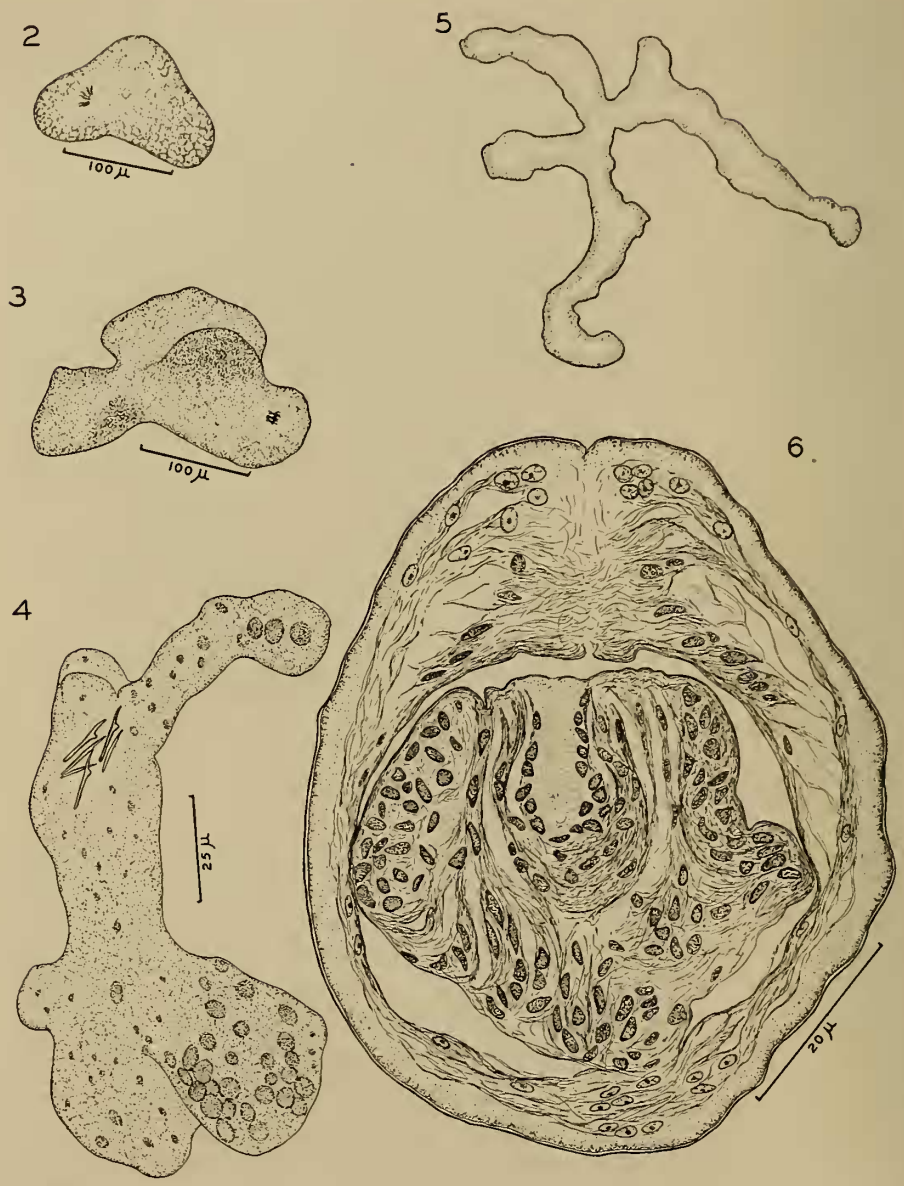
[3] Van Volkenberg, H. L. *Report of parasitologist.* Report Puerto Rico Agric. Exp. Sta. 1930: 38–40. 1931.

These beetles were collected in or near poultry yards, in particular at the Beltsville Research Center of the U. S. Department of Agriculture near Beltsville, Maryland. Three specimens of *Ataenius stercorator*, infested with proliferating larvae, were sent to the Zoological Division from Puerto Rico; the total number of infested beetles of this species, found in that locality by Van Volkenberg, is not known. No laboratory-reared beetles of any of these species were used. A few specimens of *A. cognatus*, after being kept in the laboratory for 2 weeks or longer after collection, were fed eggs of *H. cantaniana* and subsequently harbored young larvae in various stages of development. With one exception, the early stages of development described below were obtained from these experimentally infected beetles. Following experimental feeding, larvae were found in beetles after 24 hours (2 beetles), after 8 days (1 beetle), after 9 to 12 days (1 beetle, fed August 2, 4, and 5, and examined August 14), and after 11 to 14 days (1 beetle, fed August 2, 4, and 5, and examined August 16). A larva, less developed than those observed in the beetles fed 8 days previously, was found in a naturally infested beetle which also contained larvae of more advanced development, some of which exhibited completely formed cysticercoids.

Larvae were examined as fresh material and also as both stained and unstained permanent mounts. Two beetles were sectioned for observation of larvae *in situ*.

DEVELOPMENT OF LARVA IN INTERMEDIATE HOST

The youngest larvae of *H. cantaniana* observed were obtained from a beetle 24 hours after experimental infection; the identification of the larvae was based on the embryonal hooks which were 13 to 14μ long. One larva, observed soon after it was recovered from the body of a beetle, was slightly elongate and became rounded during observation; as unfixed material it was undifferentiated in appearance and disintegrated quickly. A similar elongate specimen measured 106μ long by 54μ wide. A third larva (Fig. 2) was trilobed, being about 160μ along its greatest axis; another larva (Fig. 3), more definitely lobed, measured about 200μ along its greatest axis. At least 6 small lobes or branches were exhibited by a smaller larva (Fig. 4) of unknown age which measured about 140μ along its greatest axis after having been mounted and stained with methylene blue. It is considered typical of early branching or proliferating larvae of this species; its nuclei are comparatively large and are definitely more concentrated near the tip of each branch. Apparently the first few branches elongate (Fig. 5)



Figs. 2–6.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus*. Figs. 2–3.—Obtained 24 hours after experimental feeding. Fig. 4.—Young larva, natural infestation. Fig. 5.—Sketch of branching larva, 8 days after experimental feeding. Fig. 6.—Completely formed cysticercoid. Sectioned material.

before many new buds arise. A larva recovered from a beetle fed 8 days previously had a maximum axis length of 605μ and exhibited considerable proliferation, there being 4 distinct elongate branches and 2 rounded buds. Larvae from a beetle fed 9 to 12 days previously con-

sisted of numerous branches and a few buds which represent partly developed cysticercoids. Larvae recovered from a beetle of the same lot fed 11 to 14 days previously consisted of numerous branches, buds, partly formed and completely formed cysticercoids, the latter representing the infective larvae proper.

To summarize briefly on the basis of observations on numerous larvae, the hexacanth embryo develops into lobes, then a branching, mycelium-like structure, the branches of which bear buds which may develop into new elongate branches or directly into cysticercoids. In general, on the branching larval stem, the development of a bud into a cysticercoid resembles the more commonly observed development of hexacanth embryo into cysticercoid of other species of tapeworms, except that the embryonal hooks of *H. cantaniana* remain in the basal stem, or are lost, and consequently are not involved in the development of bud into cysticercoid (Figs. 1, 7, 8). A larva early in its development, still somewhat globular except for the area of attachment to the stem, is about 35 to 50μ in diameter; the cell nuclei are closer together than are those of the proliferating stem itself. These globular structures, while remaining attached to the stem, elongate and become ovoid; with further elongation constrictions appear; the first constriction results in a larva made up of a smaller proximal region, nearer the stem, and a larger distal region (Fig. 1c). Such larvae, with one constriction, may be 70 to 85μ long by 35μ in diameter through the proximal region and about 40 to 45μ in diameter through the distal region. Cells of the distal region are the more concentrated; in the median and proximal regions the outer cells lie close together, but the inner cells have elongate projections and form a loose tissue which represents the "primitive cavity" of the developing cysticercoid. While the first constriction, mentioned above, is becoming more marked, there occurs cell differentiation in the distal region in 4 areas which represent the future suckers. At the distal tip, a few large cells are to be observed which later develop as a projection representing the future rostellum; at an early stage this projection is 10.5μ long by 7μ in diameter.

A second constriction appears proximal to the suckers, and differentiation progresses. The region of loose fibrous tissue becomes more marked, suckers become more distinct, and a narrow cavity appears in the projecting rostellum, the latter 22μ long by 8μ in diameter. An individual specimen at this stage of development is 112μ long, 102μ in diameter through the suckers, 42.5μ through the median region, and 52.5μ through the posterior region.

A cysticercoid apparently just beginning to invaginate is 120μ long. Suckers appear to be completely formed, or nearly so, but the rostellum is not completely developed. *H. cantaniana* evidently belongs to the group of cestodes in which scolex differentiation of the larva is partially but not entirely completed before invagination. Invagination itself occurs rapidly, to judge from the comparatively few larvae observed in the process.

The region of attachment to the main stem elongates as the bud develops into a cysticercoid; it is fragile and breaks or disintegrates easily during observation of fresh material.

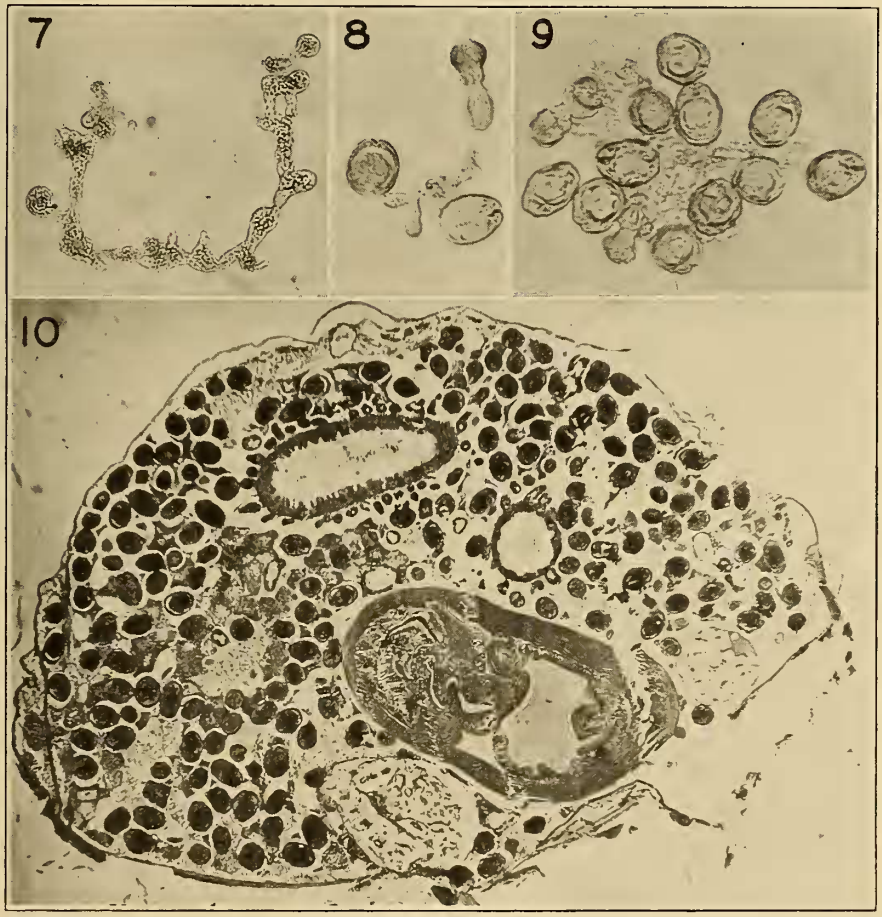
Calcareous corpuscles are first observed in young rounded forms; larvae with one constriction may contain 4 to 10 calcareous corpuscles which, as a rule, are median or distal in position. In completely formed cysticercoids as many as 40 have been counted; these are located in the inner cyst wall and thus are in the neck region of evaginated specimens.

Completely formed cysticercoids or infective larvae (Fig. 6) are spherical or ellipsoidal in shape or, in heavy infestations, may be irregularly compressed. They are comparatively small, 90μ by 68μ to 140μ by 102μ in diameter. The cyst wall consists of a thin cuticula, an inconspicuous basal membrane and sub-cuticular layer, a fibrous zone with irregular spaces representing the old "primitive cavity," and the inner cuticula. The scolex, lying in a small invagination cavity, is about 50 to 72μ in diameter; suckers are 20 to 26μ in diameter, the rostellum is about 22 to 24μ long, only the small rosteller cavity being easily observed in most material. No hooks could be seen on the scolex, although wrinkles of the cuticular lining of the rostellar cavity suggested minute hooks in certain specimens.

Completely formed cysticercoids may remain attached to the proliferating larval tissue by short stems or may lie free in the body cavity of freshly dissected beetles. Although cysticercoids become detached readily during the examination of the material, they do not evaginate readily in tap water, even when stimulated by tapping or heating the slide. Cysticercoids of *H. cantaniana* differ in this respect from those of *H. carioca* or *Raillietina cesticillus*, which evaginate much more readily.

On the basis of the limited material derived from experimental infections of beetles, it is concluded that at room temperature during mid-summer, in Washington, D. C., 11 to 14 days, as a minimum, are required for the cysticercoid to become completely formed. The time necessary for development at lower temperatures is not yet known.

Larval proliferation and development of cysticercoids appear to continue for at least 4 weeks, since in one lot of beetles, collected in mid-October and held so that re-infection was not possible, both completely formed and developmental stages were observed until early in December when the last beetle was killed. However, in some beetles,



Figs. 7–9.—Larvae of *Hymenolepis cantaniana* from *Ataenius cognatus*. Natural infestations. Fig. 10.—Section through specimen of *A. cognatus* containing numerous larvae of *H. cantaniana*. Natural infestation.

it has been noted that there were numerous completely formed cysticercoids (Fig. 9) along the branching structures, but only very few developing forms; this might be interpreted as indicating that there is a limit to the period of proliferation of the larva. Surprisingly large numbers of cysts may be found in a single beetle (Fig. 10). As reported previously, the number of cysticercoids counted in one beetle

was 1163, and in another individual, 2217; developing cysticercoids were not included in either count.

SEASONAL OCCURRENCE AND DISTRIBUTION OF INTERMEDIATE HOSTS

The dung beetle, *Ataenius cognatus* Leconte, has been collected near Beltsville, Maryland, from April to November, inclusive. According to information supplied by Dr. E. A. Chapin, this species is very common and widely distributed in the United States and is known to occur as far south as Mexico. In the vicinity of Washington, D. C., it may be collected at any time during the year when weather conditions are favorable.

Ataenius stercorator Fab. is believed to occur from Texas to Brazil and more generally in the West Indies. It has also been reported from Madeira.

Choeridium histeroides Weber has been collected in poultry yards near Beltsville, Maryland, but less frequently than *Ataenius cognatus* or *Aphodius granarius*. It is considered as being moderately common in the vicinity of Washington, D. C., and it may be found at any time during the year if the weather is favorable.

Numerous specimens of *Aphodius granarius* and *Onthophagus* spp., which also were collected from poultry yards near Beltsville, have been found consistently negative for larvae of *H. cantaniana*. Of 10 specimens each of *Aphodius granarius* and of *Ataenius cognatus* which were collected at the same time, from the same poultry yard, the specimens of *Aphodius granarius* were negative while 8 of the specimens of *Ataenius cognatus* contained larvae of *H. cantaniana*. Efforts to infect specimens of *Aphodius granarius* with *H. cantaniana* in the laboratory have been unsuccessful. On the basis of our present information, *Hymenolepis cantaniana* appears to exhibit more specificity as to its intermediate host than do other poultry tapeworms which use beetles in that capacity.

DEVELOPMENT OF HYMENOLEPIS CANTANIANA IN DEFINITIVE HOSTS

Birds were fed larvae from the beetle, *Ataenius cognatus*, as listed in table 1. No cestodes other than *H. cantaniana* were found in any bird and control birds remained free of cestodes.

As noted in table 1, one chick (a), which was examined 11 days after experimental feeding with *H. cantaniana* larvae, contained immature specimens of *H. cantaniana* about 3.5 mm. long. Chick G7068 passed eggs of *H. cantaniana* 14 days after experimental feeding; chick No. 91 passed eggs in droppings, and chick G7047 contained mature speci-

TABLE 1.—Development of Hymenolepis cantaniana

HOST	DESIGNATION OF HOST	DATE OF FEEDING	DATE OF AUTOPSY	POST-MORTEM FINDINGS
Chick	1	Oct. 26, 1932	Nov. 2, 1932	Negative
	J3	Oct. 26, 1932	Nov. 14, 1932	About 10 almost mature tapeworms
	a	Oct. 28, 1932	Nov. 8, 1932	About 12 immature tapeworms
	b	Nov. 10, 1932	Dec. 2, 1932	Negative
	91	Nov. 15, 1932	Dec. 7, 1932	Tapeworms present (eggs in feces, Dec. 1)
	G7047	Nov. 16, 1932 (ca. 500 cysts)	Dec. 2, 1932	21 mature tapeworms
	G7068	Nov. 16, 1932 (ca. 230 cysts)	Dec. 20, 1932	44 mature tapeworms (eggs in feces, Nov. 30)
	365	June 19, 1933	Died July 3, 1933	? (Bird decomposed)
	305	July 8, 1933	Aug. 17, 1933	Few mature tapeworms
	310	July 8, 1933	Aug. 17, 1933	Few mature tapeworms
	316	July 8, 1933	Aug. 17, 1933	About 10 tapeworms
	345	July 21, 1933	Oct. 3, 1933	Tapeworms present
	324	Aug. 21, 1933	Sept. 21, 1933	Tapeworms present
	406	Sept. 20, 1933	Nov. 14, 1933	Numerous tapeworms
	407	Sept. 20, 1933	Jan. 4, 1934	Negative
	445	Sept. 20, 1933	Jan. 4, 1934	Negative
	421	Sept. 20, 1933	Mar. 10, 1934	Few tapeworms
Bobwhite quail	219	Aug. 27, 1934	Sept. 28, 1934	About 113 tapeworms
Guinea fowl	294	Aug. 27, 1934	Nov. 20, 1934	About 15 tapeworms

mens of *H. cantaniana*, 16 days after experimental feedings. Chick J3, examined 19 days after experimental feeding, contained specimens with egg-filled segments, but with the eggs apparently still unripe; no eggs or gravid segments were found in the posterior regions of the intestine. It is concluded that the time necessary for development of *H. cantaniana* in its definitive host probably varies from 2 to 3 weeks.

In all, 12 chickens, 1 guinea fowl and 1 bobwhite quail have become infested with *H. cantaniana* after being fed beetles containing proliferating cestode larvae. Four chicks remained negative after being fed and a fifth chick (365), which died, was so decomposed when examined that although no worms were found the negative results are somewhat inconclusive since, had specimens been present, they might well have been disintegrated by the time the bird was examined. It is interesting to note that one bird (421) remained infested from September 20, 1933, to March 10, 1934, a period of about $5\frac{1}{2}$ months. Three birds were fed eggs of *H. cantaniana* in an attempt to demonstrate a direct life cycle, but all three birds remained negative for tapeworms.

MORPHOLOGY OF ADULT

Hymenolepis cantaniana (Polonio, 1860) Ransom, 1909. *Hymenolepis:* Worms up to 2.2 cm. long by 400μ wide. Scolex 120 to 160μ in diameter; suckers unarmed, 60 to 70μ in diameter; rostellum unarmed, 80 to 85μ long by 35μ wide, sac-like, the narrow cavity lined with cuticula sometimes wrinkled and striated in appearance. Genital pores unilateral, anterior to middle of segment margin. Testes 3, 1 aporal, 2 poral, usually arranged in a transverse row, but 1 aporal testis may be anterior and median, or dorsal and median, to other aporal testis; testes obscured rapidly by developing ovary and uterus, and at no time conspicuous in strobila. External seminal vesicle near median line; internal seminal vesicle nearly filling cirrus pouch. Cirrus pouch thin-walled, elongate, 70 to 95μ long, extending nearly to middle of mature, but not of gravid, segments. Vagina ventral to cirrus pouch, expanding into comparatively large oval seminal receptacle, for a time the most prominent structure in the segment. Ovary, when mature, sometimes extending to lateral excretory vessels and to anterior border of segment. Uterus sac-like, eventually filling nearly the whole segment and containing about 10 to 20 eggs. Eggs spherical, 45 to 60μ in diameter; oncosphere 22 to 25μ in diameter; embryonal hooks 13 to 14μ long.

Individual gravid segments or groups of 2 or 3 segments are found occasionally in droppings; however, as a rule, segments disintegrate early and individual eggs are found in the posterior portion of the intestine and in droppings. Embryonal activity has been observed in eggs still present in gravid segments of freshly collected strobilae, in eggs from fresh droppings, and also in eggs kept as long as 6 days in a refrigerator (45° to 50°F.). Embryos are not easily activated on a slide as are those in gravid segments of *Davainea proglottina* and *Raillietina cesticillus.*

Hosts.—Definitive: Galliformes (*Gallus gallus, Meleagris gallopavo, Pavo cristatus, Phasianus colchicus, Colinus virginianus* and *Numida meleagris*).

Intermediate: Coleoptera (*Ataenius cognatus, A. stercorator,* and *Choeridium histeroides*).

Location.—Small intestine, usually duodenum of definitive host; body cavity, connective tissue and, less commonly, muscular tissue of intermediate host.

Geographical distribution.—Europe (France, Spain, Italy, Jugo-Slavia and U. S. S. R.), Asia (Japan and Indo-China), South America (Brazil), and North America (United States, including Puerto Rico).

SUMMARY

Early developmental stages of proliferating larvae were obtained from 5 specimens of the beetle, *Ataenius cognatus,* which were dissected at varying periods after having been fed eggs of *Hymenolepis cantaniana.*

The hexacanth embryo was found to develop into a larva of several lobes, the latter elongating to form a somewhat branched, mycelium-like, structure; buds arose along the branches which developed into new branches or directly into cysticercoids containing the unarmed scolex characteristic of the species. Development of the bud into the cysticercoid resembles in general the development of other *Hymenolepis* larvae; the process consists of elongation, slight cavity formation, constriction, differentiation of scolex in most details and in-

vagination of cephalic region, resulting in a rounded cysticercoid. Scolex differentiation of *H. cantaniana* is partially, but not entirely, completed before invagination.

On the basis of the experimental findings, the minimum time required for development of an infective larva in the beetle host is from 11 to 14 days; proliferation of the larva and development of new cysticercoids apparently may continue for at least 4 weeks.

Development of the adult worm in the chicken requires at least 14 days and the time probably varies from 2 to 3 weeks.

Twelve chickens, 1 quail and 1 guinea fowl became infested with *Hymenolepis cantaniana* as a result of feeding branched cestode larvae obtained from naturally infested specimens of the beetle, *Ataenius cognatus*.

The beetles *Choeridium histeroides* and *Ataenius stercorator* are reported as additional intermediate hosts, on the basis of their harboring larvae similar to those found in *Ataenius cognatus* and known to be larvae of *H. cantaniana*.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETY

BOTANICAL SOCIETY

SPECIAL MEETING

A special meeting was held in the auditorium of the Interior Department Building on December 11, President W. W. DIEHL presiding; attendance 80.

Program: F. A. MCCLURE: *A garden of oriental bamboos* (illustrated with lantern).

H. H. BARTLETT, University of Michigan. Professor Bartlett discussed the activities and recommendations of the subcommittee on the reorganization of the National Botanic Garden. He emphasized the fact that the present appropriation for the botanic garden was sufficient to maintain a garden of high professional standards, especially in view of the availability of cooperating agencies in Washington. Under the proposed plan the garden would be administered by a botanist of recognized standing, as Director, under the auspices of the Joint Congressional Committee on the Library. An advisory board of directors with representatives from the Smithsonian Institution, the Department of Agriculture, and various scientific societies would also be appointed.

Following Professor Bartlett's remarks, discussion of the proposed plan ensued, and the Society took formal action approving the reorganization of the National Botanic Garden along the general lines outlined in Professor Bartlett's report. The secretary was directed to notify the Chairman of the Joint Congressional Committee on the Library of the Society's action.

262ND MEETING

The 262nd regular meeting was held in the Assembly Hall of the Cosmos Club, January 8, 1935, President DIEHL presiding; attendance 95. J. E. MCMURTREY was elected to membership.

Notes and reviews: Brief reports on the Pittsburgh meeting of the American Association for the Advancement of Science were presented as follows: Mycology, J. A. STEVENSON; Phytopathology, H. P. BARSS; General Botany, A. S. HITCHCOCK; Plant Physiology, C. F. SWINGLE; Horticulture, G. M. DARROW; Publicity, FRANK THONE. A report of the Chicago meeting of the American Society of Bacteriologists was presented by N. R. SMITH.

Program: J. R. CHRISTIE: *The development of nematode root galls* (illustrated with lantern).—Abstract published in Phytopathology, December 1934. To be published in full in Phytopathology.

J. R. SWALLEN: *The arid regions of northeastern Brazil* (illustrated with lantern).

263RD MEETING

The 253rd regular meeting was held in the Assembly Hall of the Cosmos Club, February 5, 1935, President DIEHL presiding; attendance 80. HARRY A. ALLARD and HENRY E. ALLANSON were elected to membership. Article IX of the by-laws was amended authorizing the executive committee to reinstate absentee, resigned, and expelled members.

Notes and reviews: C. L. SHEAR reviewed *Monographia Discomycetum Bohemiae*, by JOS. VELENOVSKY. (Praha 1934, 2 parts, text and plates.) This work includes 1471 species, of which 800 are new, with 40 new genera.

R. K. BEATTIE reviewed the forthcoming book on systematic botany being published in English and Siamese, by HILDA S. CUNNIFF.

Program: F. C. MEIER: *Spore collections in the atmosphere over the North Atlantic and Greenland made during the Lindbergh flight of 1932* (with lantern) —Published in full in Scientific Monthly, January 1935.

C. E. COTTAM: *Present status of the eelgrass disease along the Atlantic Coast of North America.*—Published in full as Wildlife Research & Management Leaflet BS-3, February 1935.

C. O. ERLANSON: *An adaptation of the moss, Tetraplodon for the dispersal of its spores by carrion flies.*

264TH MEETING

The 264th regular meeting was held in the Assembly Hall of the Cosmos Club, March 5, 1935, President DIEHL presiding; attendance 100. The following were elected to membership: E. G. BEINHART, H. W. BARRE, C. O. ERLANSON, RALPH M. LINDGREN, F. SIDNEY BEECHER, SABURO KATSURA, W. C. LOWDERMILK, F. L. MULFORD, HILDA S. CUNNIFF, MARGUERITE WILCOX, GUY E. YERKES.

Notes and reviews: J. B. S. NORTON reviewed the new edition of Webster's dictionary from the standpoint of its usefulness in strictly botanical work. M. C. MERRILL reviewed the latest number (Vol. 8) of the Transactions of the Bose Research Institute, Calcutta.

Program: ROBERT F. GRIGGS: *Dionaea's place in Nature* (with lantern).

A. S. HITCHCOCK: *The Grasses of the United States* (with lantern).—There are in the United States 159 genera and 1100 species of grasses. By means of slides about 40 species of grasses were shown, chosen to illustrate the advance in structure from the simple to the complex. The Bambuseae are regarded as the most primitive and the Andropogoneae the most complex, with Indian corn (*Zea mays*) the culmination of the series.—*Author's abstract.*

265TH MEETING

The 265th meeting consisted of the annual banquet and dance, held in the ball room of the Kennedy-Warren, April 2, 1935; attendance 187.

Program: WM. H. WESTON JR.: *Sex in the lower fungi.*

CHARLES F. SWINGLE, *Recording Secretary*

SCIENTIFIC NOTES AND NEWS

Prepared by Science Service

Notes

Geological Survey.—L. M. Prindle has been engaged on an examination of the Enoree Purchase Unit for the Forest Service and is now undertaking a study of the saprolites or deeply rotted crystalline rocks of the gold belt in the Southern Appalachians, especially in Georgia. It is thought that a study of the heavy minerals in the saprolite will help direct the search for the most favorable gold-bearing localities. He has turned in for transmittal to the Forest Service reports on the Uharie Unit, N. C., as well as on the Enoree tract.

Soil Erosion.—All work aiming at the control of soil erosion has been consolidated in a new soil erosion unit established by order of Secretary of Agriculture Henry A. Wallace. Under-Secretary Rexford G. Tugwell has undertaken the administrative task of organizing the new unit, which is under the immediate direction of H. H. Bennett. The consolidation affected the Soil Erosion Service, formerly under the Department of the Interior, and various phases of soil erosion investigation hitherto carried on by the Bureau of Chemistry and Soils, the Bureau of Agricultural Engineering and the Bureau of Plant Industry. Research will be conducted at ten field stations, and the large-scale demonstrations already in progress will be continued and extended.

Aviation Weather.—More detailed weather news for fliers, at slightly longer intervals, began on May 1. Observations, maps, and forecasts prepared by the U. S. Weather Bureau now go out every six hours, instead of every four hours as formerly, over the teletype circuit maintained by the Bureau of Air Commerce along the airways of the United States.

Each main airport station receives, every six hours, enough information for the preparation of a weather map of the whole United States, as well as the details of conditions in a wide area around it.

All pilot balloon observations have been advanced one hour, so that the six hour reports and the airplane observations may be received in time to be checked and analyzed for use in making the maps. Lengthening the periods of teletype transmission makes it possible to send over circuits west of Kansas City and Chicago full weather reports from ships in the Pacific and also permits some increase in reports from Canada and Mexico.

Department of Terrestrial Magnetism.—In order to expedite the transmission of scientific data between the Department of Terrestrial Magnetism of the Carnegie Institution of Washington and its magnetic observatory at Watheroo, Western Australia, the Australian Government has recently authorized the installation at the observatory of an equipment of sufficient power for direct communication with Washington, D. C. The installation has been completed and communication established with radio stations at Washington Grove, Maryland (just outside of Washington) and Fresno, California. During periods when direct communications through Washington Grove is not possible, messages are relayed through the West-Coast station. Thus it is possible for scientific information obtained at Watheroo to be transmitted to Washington without delay and schedules are maintained for this purpose.

There have been received recently in Washington an extensive series of magnetic records, control-observations, absolute determinations at field stations in Antarctica during sledge trips, etc., successfully carried out by the Byrd Antarctic Expedition II, during the period February 1934 to February 1935.

New Non-Magnetic Ship.—A first instalment of 10,023 pounds, towards the construction by the British Admiralty of a non-magnetic vessel has been included in this year's Naval Estimates presented to the House of Commons on March 6. The purpose of this new vessel is to resume the ocean magnetic-survey work which was carried on by the CARNEGIE, under the auspices of the Carnegie Institution of Washington, before her destruction by explosion and fire on November 29, 1929, in harbor at Apia, Western Samoa.

The magnetic charts published by the British and other governments for use at sea have been based in recent years to an increasingly large extent upon data provided by the CARNEGIE. There are, however, serious gaps in the present data which would have been filled if the CARNEGIE had completed her last cruise. These gaps together with a recent rapid change in the secular variation in the Indian Ocean, render the extrapolated values of the magnetic elements in the southern Indian Ocean unreliable and indicate the possibility of serious errors in future charts of this and other ocean areas. Since the Carnegie Institution of Washington has decided not to replace the CARNEGIE, the British Government, in view of her large maritime interests, has assumed the responsibility. The details of the design of the new non-magnetic vessel, the primary purpose of which will be the determination of magnetic data at sea, have not yet been made public, though it is probable that the new vessel will be larger than the CARNEGIE.

National Park Service.—J. Thomas Schneider, at the special request of the Secretary of the Interior is working on legislation calling for the preservation of historic sites and buildings. Mr. Schneider recently made a survey of European historic sites.

Study of Maternal Care.—The Children's Bureau has completed what is expected to be the first of a series of studies of community provisions for maternal care. This first study, in Hartford, Conn., was undertaken at the invitation of the Hartford Medical Society, which appointed an advisory committee of five members for the study, representing also the local hospitals.

Data was obtained as to all deliveries of women resident in the city of Hartford that occurred during two periods of three months each—May, June and July, 1933, and January, February, and March, 1934, a total of about 1,200. The necessary information was obtained by means of interviews with the attending physician, by study of the hospital records, by reports from the visiting-nurse association, and by interviews with the mothers themselves three months or more after the delivery. These interviews were always obtained with the consent of the physicians attending the women.

The purpose of this series of studies is to ascertain: the type of maternal care received by an unselected series of mothers in different localities; and the proportion of these mothers having abnormalities or morbidity.

The results of the present study are now being analyzed in preparation for the writing of the report.

Paleontological Society.—The Paleontological Society of Washington was organized Wednesday evening, December 19, 1934, in the U. S. National Museum. The purpose of the Society is to promote a closer understanding between the fields of biology and paleontology; to offer opportunity for open, informal discussion of biological and paleontological theory; and to provide a suitable place for the presentation of original and technical papers of general interest to research workers in both of the fields of science.

The following officers were elected: Honorary President, DAVID WHITE (since deceased); President, CHARLES W. GILMORE; Vice-President, REMINGTON KELLOGG; Secretary, LLOYD G. HENBEST; Treasurer, G. ARTHUR COOPER; Member of the Council, S. F. BLAKE. Meetings are held the third Wednesday evening of each month. The programs at present are planned to include brief communications, reviews, etc.; regular papers; and to provide at least one-half of the time for informal discussion on a previously announced subject.

International Zoological Congress.—The Twelfth International Zoological Congress will be held in Lisbon, Portugal, under the patronage of the President of the Portuguese Republic from Sunday, September 15th to Saturday, September 21st, 1935. Sessions of the Congress will be held at the University of Lisbon under the presidency of Dr. A. RICARDO JORGE, Professor of the Faculty of Sciences of the University and Director of the Zoological and Anthropological Department of the National Museum of Natural History.

Field Conference of Pennsylvania Geologists.—The fifth annual meeting of the Field Conference of Pennsylvania Geologists will have its headquarters at the Academy of Natural Sciences in Philadelphia on Friday, May 31st–Sunday, June 2nd. Registration and museum tours will take place from 9 A.M. to 12 M. on Friday, May 31st, and at 2 P.M. the first of the trips will leave Philadelphia to observe the physiography of the Piedmont upland and the adjacent Coastal Plain terraces around Philadelphia. An alternative trip to localities of mineralogic and petrologic interest to the north of Philadelphia will also be conducted on that afternoon. On Saturday, June 1st, the Conference will leave the Academy at 8 A.M. on a general trip through the crystalline and intrusive rocks of the Piedmont Belt in the Philadelphia area. On Sunday, June 2nd, they will leave at the same time to examine the lower Paleozoic formations and their relations to the pre-Cambrian rocks in the area west of Philadelphia. This trip will go as far west as Quarreyville which is the type area of the Martic overthrust. On Monday, June 3rd, a post-Conference optional excursion to the Coastal Plain of New Jersey will be conducted.

NEWS BRIEFS

A Pan-American pact for the protection of art galleries and scientific museums during war was signed at the White House on April 15 by representatives of Bolivia, Brazil, Chile, the Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, the United States and Uruguay. By the terms of the pact, certain cultural buildings, sites and monuments, marked with a banner of peace, are to be considered neutral zones in time of war, and as such shall be immune from airplane bombing and other acts of hostility.

The National Zoological Park has received an allotment of $680,000 from PWA funds. It is planned to build an addition to the bird house, a new elephant house and a house for small mammals, with special accomodations for apes. It is also planned to provide a machine shop.

Two unusual meteorites, both seen to strike the earth in North Carolina, have just been received by the Smithsonian Institution, which will cooperate with the North Carolina State Museum in their analysis.

Personal Items

Dr. Nolan D. C. Lewis, director of laboratories at St. Elizabeth's Hospital, has been given leave of absence for the purpose of making a survey of existing research projects and methods of treatment and control of dementia praecox, as a preliminary step in a campaign against this disease financed by the Scottish Rite Masons of the northern jurisdiction of the United States.

The Remington Honor Medal, highest award in pharmacy, has been given for 1935 to Samuel Louis Hilton, retail pharmacist of this city, in recognition for his many years of service to his profession, and in particular for his efforts in connection with the building of the American Institute of Pharmacy, recently completed.

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VOL. 25 JUNE 15, 1935 No. 6

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OF THE

WASHINGTON ACADEMY OF SCIENCES

PUBLISHED MONTHLY

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BIOLOGY.—*Biology and human trends.*[1] RAYMOND PEARL, The Johns Hopkins University.

I

To discuss adequately in a brief address the assigned subject "biology and the social consequences of its advances" is plainly a large order, and one beset with considerable difficulties. For on the one hand biology as a science is still largely in the descriptive and historical phase of its development, and sociology is even more so, with the consequence that an account of the significant achievements of these sciences cannot be expressed in the concise and rational short hand that is so useful in physics; and, on the other hand, to appraise the theoretical consequences of scientific discoveries implies a certain skill in the dangerous art of prophecy. Not having any noteworthy aptitude as a prophet I can only put before you, in all modesty, the views of one biologist about some of the more evident relations between certain well-established biological facts and principles and some of the more characteristic features of the collective behavior of mankind. While I cannot speak with officially sanctioned authority for more than one particular biologist it does seem absolutely certain that just in proportion as any of the sciences, including biology, succeed in their effort to establish sound general principles and laws, just in that proportion will their advances be inevitably reflected in collective human behavior. The thoughts and actions of all mankind were permanently and irreversibly altered from what they were before, after the *Origin of Species* had been published in 1859. A corresponding alteration, more or less significant as the case may be, occurs whenever a *real* discovery in science is made, or a sound generalization established.

II

In the great Symphony of Life there appear to be three, and only three, main, basic biological themes, out of which come all the pleasant or harsh, useful or harmful, simple or complex counter-melodies,

[1] Received March 22, 1935.

harmonies, and dissonances of the business of living. These main basic themes are:

First: The urge to individual personal *survival* here and now. This appears to be an attribute of all living matter.

Second: The urge to *reproduction* which again appears to be a property of all that lives.

Third: *Variability*, once more common to all living matter, in both its genetic and somatic aspects, the one leading to the observed differences or variations between individual organisms, the other embodying the differences in the same individual at different times in its life.

Finally, it is to be remembered that it is impossible to discuss or even to imagine life or living things without taking into account the rest of the universe in which they exist. So then we must add to our material for discussion one more item that corresponds roughly to the fiddles, flutes, horns, printed music, desks, and other *impedimenta* not musical *per se* but without which a symphony would never reach the ears. This item is:

Fourth: The *environment* that conditions and in some degree determines all vital phenomena.

Let us now examine each of these four items in some detail.

The urge to survival[2] may fairly be regarded as the most fundamental attribute of living things and is therefore placed first in the list. It may be well to point out at the start that in its essence this urge to survival is rather completely and uncompromisingly selfish. To the best of its ability the individual organism so conducts its affairs as to continue living just as long as possible, regardless of what other organisms may do or think about it. When extinction threatens, every resource is brought to bear to fend it off. Basically this is what underlies the struggle for existence. Out of it, associated with it, and because of it come great ranges of biological phenomena that we have, for combined reasons of convenience and pedantry, departmentalized: such as food getting, metabolism and nutrition, cellular and humoral defense mechanisms furnishing immunity and resistance to disease, protective shelter seeking and building, natural selection, and in good part evolution itself.

[2] There are curious aspects to this universal urge to individual survival. One of them is the biological uselessness of much of it. It would be extremely difficult, if not impossible, to find any rational biological purpose served by the survival of the individual after it has reproduced itself. Yet in not a few organisms, including man, there is normally a considerable part of the life span lived after adequate reproduction has been accomplished. Living grandparents, great grandparents and celibate clergymen are among Nature's gaudier examples of Thorstein Veblen's "conspicuous waste" in the realm of pure biology.

As a matter of observed fact this survival urge is primal and deeply rooted. Whenever and wherever we see its fundamental selfishness apparently in abeyance or even much abated, and seemingly replaced by altruism or "mutual aid" as it has been called, we may be sure, I think, that one or the other of two things has happened. Either, as among the invertebrates (especially the social insects) and the lower vertebrates, the "mutual aid" is not individually motivated but is a mechanistic group consequence of caste differentiation and integration, with no more (and no less) of an altruistic element in it than there is in the cellular differentiation and integration in the embryonic development of the individual; or, as in man and to some extent among his nearest relatives, complex psychological elements have been added to the picture in the course of evolution, which may seem at times to overwhelm and obliterate the more primitive and deeply rooted biological urge. The most obvious of these added factors amounts really to a more enlightened self interest—that is to say a belief that for the present and until times get much worse it will be likely to conduce more effectively to individual survival to play along with and help one's neighbors in the crowd.

This statement is, from the necessity of brevity, much too bald and apparently dogmatic in its form, and wants more explanatory elucidation and development than we shall have time to give it. But I think it essentially conforms to at least a part of the reality. It is reasonable to suppose that the individual soldier ant is unaware of the fact that its activities and efforts are of benefit to the social group (the colony) to which it belongs. On the contrary it seems likely that when it fights it does so because it is its inherent and entailed nature so to do. In fighting it is expressing its own will-to-live or urge to survival, and in the only way of which it is capable. On the human side, in thinking of the personal motivation of altruistic behavior I am always reminded of a speech of Brotteaux in *Les Dieux ont Soif*, perhaps the greatest novel Antole France ever wrote. It is (I quote from Allinson's translation): "What I am doing now, the merit of which you exaggerate,—is not done for any love of you, for indeed, albeit you are a lovable man, . . . , I know you too little to love you. Nor yet do I act so for love of humanity; for I am not so simple as to think . . . that humanity has rights. . . . I do it out of that selfishness which inspires mankind to perform all their deeds of generosity and self-sacrifice, by making them recognize themselves in all who are unfortunate, by disposing them to commiserate their own calamities in the calamities of others and by inciting them to offer help to a mortal resembling them-

selves in nature and destiny, so that they think they are succouring themselves in succouring him."

Man's behavior, and particularly his social behavior, is motivated by so complex a set of physiological and psychological factors, appetites, emotions, and reasons, as to be extremely difficult to disentangle in a particular instance. But it may safely be said that whenever he curbs his primal urge to personal survival, he does it for secondary reasons superimposed upon his natural, protoplasmic will-to-live. Many of these reasons are, collectively, what we call social. They represent purposeful adaptations in what Wheeler has convincingly argued is the next emergent level above the individual organismal. In most human beings these secondary social adaptations of behavior are still somewhat incomplete and imperfect, as clearly appears in times of great stress or danger. And the extent to which the highest forms of human altruistic social adaptations have real and enduring survival value, has yet to be measured. It can be argued with some plausibility that why they give the appearance of having some survival value, or at least of not being positively harmful, is because they became even moderately widespread only during that recent portion of human history in which living has been relatively easy for all mankind. It has been relatively easy for two reasons: Low density of population, in general; and rapidly increasing knowledge of applied science with its accompanying industrial developments. In a world where getting a living was easy, altruistic social relations were correspondingly easy. Instances and localities of a real struggle for existence between individual men (other than during large caliber wars or in the processes incident to the assumption of the "white man's burden") have been rare in this world since the beginning of the nineteenth century. And few have ever seriously alleged that war is an altruistic enterprise; nor is it at all uncertain that the pleasures of "civilizing" backward peoples are, like those of condescension, singularly one-sided.

The urge to reproduce is second in power, if at all, only to that for survival. This basic attribute of living material, like the other, includes in its scope great ranges of academically labeled and pigeonholed biological phenomena—of which among the more important are perhaps population growth with its part in the struggle for existence and natural selection; and heredity with its concomitants of development and growth. For heredity is most clearly to be apprehended as an aspect of reproduction. Living things do not merely reproduce; they reproduce *themselves*. This fact makes it clear that,

philosophically viewed, the urge to reproduction is really a part—an extension if you like—of the primal urge to survival. If the individual cannot ensure his own indefinite earthly immortality he can and does try *his* very best to see that his stirp shall keep on living forever and ever. Naturally this self-reproductive process tends towards social as well as biological stability.

Genes are almost incredibly stable and resistant to alteration in the natural and usual circumstances of life. For something over fifteen years there has been going on in my laboratory a continuous experiment designed to test this point in a simple and direct way. Tonight I make the first public statement about it. This experiment has now included over 300 successive generations—perhaps the longest bit of controlled breeding ever carried out, with the results in each successive generation carefully observed and precisely recorded. Allowing 30 years as a round figure for the average duration of a human generation the time equivalent in human reproduction of this experiment would be of the order of 9000 years—considerably longer than the total span of man's even dimly recorded history. The objective of this experiment with *Drosophila* has been to see whether a simple Mendelian ratio involving but one character would or could be altered in the passage of time by such natural forces as selection, different systems of breeding (such, for example, as that called "grading up" by livestock breeders), and wide alterations of the environment nearly up to the limits of the organism's ability to go on living at all. The plan of the experiment is a simple one. It started by crossing a normal fruit fly (*Drosophila melanogaster*) possessing the normal wings characteristic of the species, with the pure mutant form *Vestigial*, so-called because the wings are reduced to non-functional vestiges. This wing characteristic is associated with a single gene. In the next generation all the flies produced by the pair with which we started had normal standard wings, normal being dominant to vestigial. These flies of the first cross-bred generation were then mated to pure vestigials (back-crossed to the recessive parent, in technical genetic language) to produce the second cross-bred generation. Of the offspring of these matings approximately one-half had normal wings, because they carried the original normal wing gene, and the other half had vestigial wings, all this being in accord with regular Mendelian expectation. The vestigial winged flies of this and all later generations were killed and thrown away as soon as they had emerged and been counted. The normal winged flies were again mated to pure vestigials to produce the next generation. And so on with undeviating regularity for

more than 300 generations. What the plan means in briefest terms is that since the rather stupendously long time (measured in generations) when the experiment began the only hereditary determiner (gene) for normal wings that has ever been in the system is the one that was contributed by the one single normal wild type fly with which we started. All the normal winged flies now appearing in the populations of the successive generations of the experiment have normal wings only because their *Urgrossvater* had them 300 generations ago, and for no other reason.

The net result of the experiment has been to show that the gene involved has preserved its initial characteristics unaltered. So also has the cellular mechanism for the shuffling and sorting of the genes in each generation. The approximately 50-50 ratio of normal winged to vestigial winged flies appears generation after generation with somewhat wearisome regularity. The demonstration of the inherent stability of the genic mechanism of heredity that this experiment has given is extremely impressive.

Analogous phenomena of organic stability are observed in nature. There are considerable numbers of firmly established instances of organisms living today that are *specifically* identical with their progenitors in earlier geological eras. Among the Foraminifera one species (*Lagena sulcata*) has persisted unchanged from Silurian times down to the present; one species (*Globigerina bulloides*) from the Devonian to the present; two species from the Carboniferous; two from the Permian; four from the Triassic; seven from the Jurassic; and fifteen from the Cretaceous. The significance of these cases cannot be overemphasized. When it is comprehended that organisms now living have not changed by a perceptible amount from what they were millions upon millions of years ago in paleozoic times in those *minutiae* of structure upon which systematists base their specific distinctions and descriptions, the conservatism and stability of nature begins to be realized.

In human biology the conservative and stable element of true biological heredity is supplemented and reinforced by what has been variously called "social heredity," or tradition, or the mores of the group to which the individual and his stirp belong. This is, of course, not inheritance at all in a proper biological sense. It is rather an environmental matter at bottom. A born Englishman transported to America as a child may, and in fact usually does, come as a man to think and act like an American. But to make him do this if he lives his whole life in England among the people of his kind would be vir-

tually impossible. And it is a matter of statistical fact that vastly more human beings live out their lives not far from where they were born and among their kind of people, than migrate or are transplanted into realms of other traditions and mores. In consequence "social inheritance" or tradition plays an enormous, but usually underestimated part in determining the individual and collective behavior of human beings. Its effects have not infrequently been confused with those of true biological heredity. Masses of data have been collected to show that near relatives, particularly fathers and sons, frequently follow the same professions or callings. It is often quite erroneously concluded that such facts prove a biological inheritance of talent or ability, either in general, or for a particular calling, or both. Such data are inherently incapable of proving any such a conclusion. The observations can be much more simply and satisfactorily accounted for in the main by the operation of the purely environmental factors of familiar contact from childhood, training, easy opportunity of entrance, and the social pressure of tradition; in short by "social" not biological inheritance.

Our third unique and universal biological principle, variability, has two aspects, as has already been pointed out. No two living organisms are exactly like each other in all particulars, and no single organism is precisely the same at any two moments in its lifetime. The first of these aspects is the only one that is conventionally called variability. It is mainly caused by the combined interaction of genetic shufflings and recombinations and the environment. The second aspect of organic variability is usually and conveniently called adaptability. It is an odd and remarkable phenomenon. The unique thing is not that organisms are more or less fitted or adapted to the circumstances in which they find themselves. Inanimate objects of various sorts, and particularly that category of them that we call machines are this. It is true that the adaptations of organisms and machines are brought about in different ways. But the fact of adaptation is present, and in principle identical, in both. We are, however, not concerned here with adaptation, but with self-started and self-controlled *adaptability*, which organisms have and machines do not. Organisms incessantly change and alter themselves to meet the fleeting changes in their circumstances. No living organism ever stays put. When it does it is dead, and in dying has passed into a wholly different category of matter.

The process goes even deeper than change and adaptability in behavior. The very material substance itself that makes up the living

organism is constantly changing. What then does "personal identity" connote? What we are pleased to call the same identical man at the age of 70 years is composed of extremely little if any of the same material substance that made him up when he was 20 years old. Probably there is not a single molecule in him at 70 that was there at 20. In the intervening years the only thing about him that has survived is his *pattern*, a sort of transcendental or spiritual wraith through which has flowed a steady stream of matter and energy. There is a profound truth embodied in Cuvier's old comparison of a living organism to a whirlpool. It is the pattern that is the essence of the business. It alone endures. And it is constantly altering and adapting itself to changing circumstances. Especially is this true and important of the psychological panel of the total pattern of the human organism. It is this aspect of adaptability, the capacity of organisms for change ending only with death, that seems to be more important in its social consequences than its teleological aspect, if indeed we are prepared to admit the reality of the latter at all, as some are not.

We may conclude this hasty survey of basic principles with a word or two about the environment. The *effective* environment of any particular living organism is determined by the pattern of that organism, just as truly as the pattern of the organism is in part at least determined by the environment. For a particular man, and for a group of similar men, but not for any mouse, the relative honesty of his banker and the urbanity of his dean are highly important elements in the effective environment. And what makes them so is not the bankishness of the banker nor the deanishness of the dean, but the pattern of the particular man of whom we are speaking—a pattern not shared by the mouse. In short the relation between organism and environment is everywhere and always mutually reciprocal and as man is the most complicated and manifoldly diverse in his capabilities of all organisms, so also is his effective environment the most complicated.

More extensively and more effectively than any other organism he *makes his own environment*. He is constantly altering it in the hope of making it better. But such is the interplay of the contradictory biological elements in his nature that he dislikes and resists any alteration of his environment by anyone else than himself or the group of people similar to himself to which he belongs. The social and political consequences of these opposing attitudes are far-reaching and encompass within their range the greater part of our communal troubles in this imperfect world.

The full implications of the reciprocally determinative influences of

organism and environment seem to me to have been generally somewhat less than adequately valued in the last century's development of biological thought, and certainly an extremely inadequate amount of first-rate research has been put upon the matter. This is partly an obvious consequence of the trend given to biological philosophy by Darwin, Galton, Weismann and Mendel, with their emphasis upon the entailed or endowed element in the whole biological picture. In human biology particularly the rôle played by heredity has come to take on many of the aspects of religious dogma. Indeed it has been urged that eugenics should be overtly espoused and developed as a religion. And all this has been going on in a world where consciously planned and directed alterations of environmental conditions have had far-reaching and profound biological effects upon whole populations, not alone in the field of public health but in many others. Every geneticist knows that the final expression in the individual of each hereditary determiner is conditioned by the environmental circumstances under which its development is undergone. Yet very little has been done in the way of attempting to analyze thoroughly and penetratingly the biological effects of environmental conditions upon human beings.

In truth science, perhaps in common with all other modes of human thought, has a seemingly ineradicable tendency to crystallize its temporarily successful philosophies into dogma, and having accomplished the crystallization proceeds to the scourging of whatever skeptics and heretics may appear. Public health workers sometimes display a religious attitude toward their achievements as intense as the crusading zeal of the eugenists for their dogmas. Only a few hardy souls throughout history and at the present time seem able to realize for longer than brief periods that new knowledge is more often than in any other way engendered out of skepticism by hard work, and that religious attitudes and modes of thought for however noble a purpose enlisted not only have nothing whatsoever to do with science, but are the most effective hindrances to getting new knowledge yet heard of.

III

Let us now turn to the examination of some of the more conspicuous and far-reaching social consequences of the basic biological principles we have briefly reviewed. The three most obvious and important ones are, I think, that:

1. Man is enjoying better health and individually surviving longer

than ever before, likes it, and intends to go farther along the same road.

2. He is vaguely conscious of being more crowded than ever before, and finds the various consequences of this crowding increasingly unpleasant, but chiefly because it threatens that enhanced survival that is always his first and deepest biological concern.

3. Therefore he is groping about to find ways to alleviate the progressive overcrowding and preserve the health and survival gains he has made; trying a great variety of experiments, some of which are sensible, others highly dubious, and a few completely idiotic.

For the sake of clarity these three statements need a little expansion. The urge to survival is the ultimate biological motivating factor that has transferred the maintenance and improvement of health from an individual to a social concern. The gains in this field have been enormous. How enormous perhaps only a statistician can appreciate. This is not the place, nor is there any need, to go into the question of how they have been achieved. But the interesting thing about the case, broadly viewed, is that without the abatement by a single bit of that basic individual selfishness in which the biological urge for survival is rooted, it has been perceived that this urge can be most effectively served so far as health is concerned by making a social matter of a great part of it. Assuring a pure water supply and innocuously disposing of the waste matters of living are things that the individual simply cannot do well. Society can. And the social progression of the urge to survival in the field of health is by no means at an end yet. In two directions we may confidently look forward to great further changes and advances in the rather immediate future. In the first place, whether we or the physicians like it or not, it seems clear that the maintenance and improvement of *individual* health is going to become more and more completely a social matter. The basic reasons are two-fold, partly because of the continued normal evolutionary further growth of the same ideas and considerations that have brought us to where we are now regarding public health; partly because of economic and political considerations. The number of persons who at the present time get inadequate medical care because they cannot individually afford to pay for adequate (and lacking it endanger other peoples' health) is so large that as a group they are already in a position politically to demand and get necessary medical service, and may reasonably be counted upon shortly to do so. In the second place it seems reasonable to suppose that advances in medical science are going to continue. The last seventy-five years —an exces-

sively small fraction of mankind's earthly history—have witnessed more progress in knowledge of disease and its effective treatment and prevention, than was made in all the time that went before. And objectively viewed the rate of advance in medical discovery seems plainly to be accelerating rather than slowing.

Turning now to the consideration of the social consequences of the urge to reproduce it is immediately to be noted that the growing consciousness of overcrowding—too many people in the world for comfort—is not the resultant of such simple matters as lack of space in which to build dwellings or to move about, or of inability to produce food enough to satisfy the collective hunger. It is true that the total number of living human beings on the globe at this moment is probably something closely approaching two billion. But the gross land area of the globe is about 35 billion acres, so that on an equal parcelling each individual man, woman and child would have over 17 acres. If the total population of the earth were to be forcibly put upon the smallest of the continents—Australia—there would still be, on an equal division, well over an acre for each individual. Similarly relative to food whatever trouble there is relates to distribution rather than production. Such famines as occur now happen not because there is not enough food produced to feed everyone, but because the complex economic mechanism of getting it to the hungry works imperfectly.

The social consequences of population growth present a much more subtle and complicated problem than mere space or food. The suggestion just made that the total land area of the globe might be equally divided per head of population is an obviously fantastic one, with only a sterile arithmetic meaning. Not all the land is equally useful for sustaining human life either directly or indirectly. Some of it is of no use whatever. And this brings us to the crux of the population problem, which is that each unit of the population must somehow or other *get its living*. All other forms of life except man get their living by one or the other or a combination of two direct ways. These are (1) by preying upon other living things, plant or animal; or (2) directly converting inorganic materials into living substance. Man today gets his living by indirect processes conveniently labelled economic. He is in the main employed in doing things that he can trade with somebody else for the biological requisites for living. The population of the world has now become so large, and the discoveries and applications of science have made the producing of the things that can be traded so much easier than it used to be, that great numbers of people all over the world find themselves unable to get a living by this process

that was formerly so relatively simple. The rapid development of the industrial type of civilization in the nineteenth century made the gloomy prophecies of Malthus at its beginning look silly. The population grew at a tremendous pace when he thought its growth would be checked by want and misery. And people were having, by and large, a grand time while their number was increasing; because they were experiencing the enormous improvements in the physical comforts of living that came with the advance and applications of science. But these very factors, plus the enhanced survival rate coincident with the development of public health, caused the ugly spectre of unemployment to rear itself higher and higher until it has now become the most serious problem that humanity faces.

It is to be noted at this point that in modern civilization, as a normal consequence of the relation of individual man's biology to his age, approximately 50 per cent of all human beings have to earn the livings not only of themselves but also the major part of that of the other 50 per cent. Man develops slowly. Children are incapable of earning their own livings before they are about 15 years old, and have passed approximately a sixth of their total life span, and between a third and a fourth of their average life duration. At the other end of life, for the great majority of human beings over 50 years of age their living must come in whole or in considerable part either from the efforts of the active workers between 15 and 50, or from what they themselves were able to save while they were in their productively efficient ages. In practically all countries the sum of the numbers of persons under 15 and of those over 50, is almost exactly equal to the number of those between 15 and 50 years of age. But over and above this burden, that may fairly be called a normal biological one, the world's workers are now called upon to support the unemployed. A considerable part of the unemployed are so because they are unemployable—not sufficiently fit and able in a biological sense to make an honest living in a world organized as this one is. These unfit organisms are kept alive by the rest of society for no realistically demonstrable reason other than that they were once born, and by being born somehow placed upon the rest of mankind what has gradually come to be regarded as a permanently binding obligation to see that they do not die. The remainder of the unemployed are so because there are too many fit, able and employable people in the world to do the necessary world's work, the aggregate amount of which has been, is being, and will continue to be steadily reduced by discoveries and improvements in the sciences and arts.

Mankind is trying in several ways to meet this situation. The first and in the long run perhaps the most important way is by reducing its reproductive rate through the practice of contraception—birth control. It has been seriously alleged and with at least some justification, that even the admittedly imperfect techniques of contraception as they are now known constitute the most important biological discovery ever made. While historians of the subject attempt to show that the practice of contraception is almost if not quite as ancient as man's recorded history, actually the birth rates of large population aggregates did not begin to be sensibly affected by it until roughly the last quarter of the nineteenth century; that is to say since the beginning of the rapid development of the highly organized, integrated and urbanized industrial type of civilization. At the present time the effects of contraception on the birth rate are plainly apparent over large and leading parts of the world's population, and are growing at a rather rapid rate.

The practice of birth control is a thoroughly sound, sensible, and in the long run effective method of meeting the problem consequent upon the biological urge to reproduction operating in a universe of definitely limited size. The only objection of importance that can be urged against it is that it has led to an unfavorable differential fertility. The socially and economically more fortunate classes of mankind have practised contraception more regularly, frequently, and effectively than the less fortunate social and economic classes, with consequently reduced reproductive rates. It is contended that this has brought about a steady deterioration and degeneration of man as a species, and will continue to do so until all progress is stopped. After prolonged study of the matter it is my opinion that the alleged detrimental consequences of this class differential fertility upon the aggregate biological and social fitness and worth of mankind, while doubtless present in some degree, have probably been greatly exaggerated in the reformer's zeal to make his case. This is not the place, nor is there time, to state and document all the reasons that have led me to this view. But there are certain considerations that must be mentioned because they have been so consistently overlooked or suppressed. The first is the tacit assumption that lies at the very root of the argument. This assumption is that generally speaking and with negligible exceptions the more fortunate social and economic classes are in that position because they are composed of not only mentally, morally, and physically, but also genetically superior people. But it may be alleged with at least equal truth that these very people who

are regarded as mentally, morally, and physically superior are that way in no small part only because they and their forebears have been fortunate socially and economically. The analogy often drawn between human breeding and live stock breeding is in part specious and misleading. In animal breeding it has been learned that the only reliable measure of genetic superiority is the progeny test—the test of quality of the offspring actually produced. Breeding in the light of this test may, and often does, lead to the rapid, sure, and permanent improvement of a strain of livestock. But when the results of *human* breeding are interpreted in the light of the clear principles of the progeny test the eugenic case does not fare so well. In absolute numbers the vast majority of the most superior people in the world's history have in fact been produced by mediocre or inferior forebears; and furthermore the admittedly most superior folk have in the main been singularly unfortunate in their progeny, again in absolute numbers. No one would question the desirability of the free multiplication of people who are really superior genetically. But in human society as it exists under present conditions of civilization many a gaudy and imposing phenotype masks a very mediocre or worse genotype, and *vice-versa*. And most eugenic selection of human beings is, and in the nature of the case must be, based solely upon phenotypic manifestations.

Naturally it is to be understood that what has been said does not refer to the problem of the really biologically defective and degenerate members of society. There the eugenic position is sound and admirable in principle. The breeding of such people must be stopped; and by compulsory measures. Voluntary birth control will not help appreciably to the solution of the problem, for the persons concerned are not of a sort to make effective use of contraception. If all the contraceptive techniques in the world were made fully available to them they would still go on breeding. There are but three ways, all somewhat imperfect, of dealing with them; they must be segregated, or sterilized, or denied any aid in the struggle for existence and thus allowed and encouraged to perish because too unfit biologically to make livings for themselves with their own unaided resources.

One final point and I shall have done with this phase of our subject. It is a curious fact that at every stage of man's history from at least the time of Plato, and indeed of Theognis of Megara a century before that, there have been those who have been just as certain as some present day eugenists are, and just as deeply grieved, that mankind was going rapidly to the dogs because the right kind of people

were not breeding enough and the wrong kind of people were breeding too much. Perhaps men are nearer the dogs now than they were in the Alexandrian age; but I venture to doubt it. The evidence seems to me overwhelming that mankind is, on an average, mentally, morally, and physically much superior today to what it was when Socrates was abated as a public nuisance.

So much for birth control and the eugenic objections to its alleged consequences. We turn now to the most ineffective, cruel, and altogether foolish large scale method by which society tries periodically to ameliorate the consequences of the biological urge to reproduction, namely war. If this characterization is reasonably in accord with reality why do we go on having wars? The reason has been stated with precision by a clear thinking human biologist, C. C. Walker, in the following words:

"The natural striving after security by one people, that is to say its natural endeavors to exist, must affect the security of other peoples. Because when a people endeavors to ensure its existence, by reason of its automatic reactions to the problems connected with food-supply, security, and social stability, its endeavors will conflict with the strivings of other peoples who are also subject to the same environmental problems. Each people is only trying to exist. When a people considers that its existence is threatened by a particular environment, . . . to such an extent that no adaptation to the environment will suffice, it is forced to attempt to alter that environment. But other people may consider that any alteration of that environment affects its own existence. The result is war."

Is there any reason to suppose that this biologically natural process, with its characteristic of almost rhythmic recurrence, will ever come to an end? It seems to me there can be such a hope only in the long —very, very long—run. And the only reason I can see for even this deferred hope is the already great and rapidly increasing ease, speed, and cheapness of transportation and communication between all parts of the world. The slow but steady and sure biological effect of easy getting about will inevitably be more and more interbreeding, with a gradual lessening of the racial and national differences between human beings. In the far-off end all mankind will presumably be a rather uniform lot; all looking, thinking, and acting pretty much the same way, like sheep. National or racial isolation has even now become extremely difficult to maintain; indeed in a quite literal sense the attempt to maintain such isolations already threatens group survival in not a few instances. In the long run they cannot and will

not be maintained. Just in proportion as they diminish so will the frequency of wars diminish. But the diminution seems likely to be at a fearfully slow rate; it will be a long time yet before the *last* war is fought. And a low cynic might suggest that even war, horrid and stupid as it is, would be preferable to that deadly uniformity among men towards which we are slowly but surely breeding our way.

Society here and abroad is just now experimenting with a whole series of internal readjustments that are being forcibly imposed upon temporarily dazed but always adaptable populations, in the hope that out of them will come a real and permanent solution of the problem that man's urge to reproduction has saddled upon us. All of these experiments appear to fall into a few simple categories when realistically examined. They all stem from and put into practice one or the other of two ideas, neither of which finds unqualified support in the science of biology. The first of these ideas is that it is best to let one individual in a group run the group's affairs; permanently, absolutely and without interference, on the philosophy that averaged opinion and averaged action are as stupid, inefficient and unreal as an averaged egg is innutritious and unreal. The other and opposite idea is that it is best to have the whole group run the business as a whole, allowing no individual any powers except as a merely mechanical executor of the group's will, on the philosophy that no individual is really superior to another and that therefore in averaged opinion and action wisdom alone resides. In their practical implementation, performance, and effects both ideas turn out to be singularly alike. Both alike scorn the intermediate idea of true democracy. And finally both attempt to solve the problem that is pestering the world by a simple procedure universally regarded as criminal when practiced by an individual. It is that the more abundant life is to be assured to a too abundant people by stealing goods from the prudent and efficient, and then giving them to the imprudent and inefficient. Since there are always a great many more of the latter kind of people than of the former this turns out temporarily to be the most effective political device ever heard of. Whether it will prove to be so permanently is less certain. It has been pointed out earlier in this paper that adaptable as man is there are nevertheless elements of conservative stability in his biological make-up whose roots go back to the very beginning of his evolution. And in that perfect state of society envisaged by our major prophets, where "economy of plenty" will assure, as we are told, that no one will have to work *much* for a living, and where the higher philosophy that holds "human rights above property rights"

(without perhaps clearly understanding what it means by either) assures that in any event everybody shall be kept alive at public expense whether he works or not, is there not the barest possibility that there might appear a somewhat general inclination on the part of the more intelligent members of the group to opt for the philosophy rather than for the communal work (however slight in amount)? If anything like this should happen might not the economy of plenty some day find itself once again in a parlous state of unplenty? Not being myself a dependable prophet I venture no answer. But in any case, and regardless of details, it is difficult to convince a biologist that a social philosophy will endure for any great length of time that deliberately and complacently loads upon the always weary backs of the able and fit an evergrowing burden. If there is one thing certain in the science of biology it is that no species or variety of plant or animal has long survived that was intrinsically incapable of making its own living. There is *somewhere* a biological limit to altruism, even for man. A large part of the world today gives the impression that it is determined to find the exact *locus* of that limit as speedily as possible.

IV

Up to this point the discussion has been of the social consequences of firmly established biological principles. In what regions of biology may there be expected with some confidence developments new in principle, and with important implications for human behavior, thought, and social relations? Probably not, one is fairly safe in saying, in such fields as morphology, embryology, or taxonomy. The advances in the field of genetics, which has to a considerable degree dominated biological thought during nearly a half century and will probably continue to for some time yet, will inevitably have an increasing influence on human affairs as the meaning of its advances is better understood. But this influence seems on the whole likely to be more of a negative than positive character—a matter of avoidances, taboos, and prohibitions rather than of positive contributions to human biological progress. Heredity represents the entailed side of biology—things given—about which it is extremely difficult really to *do* anything effective in the face of other compelling elements of human life and living, especially those elements belonging in the psychobiological realm.

It seems probable that advances likely to be made in physiology and psychobiology may profoundly alter human affairs and outlooks

in the not very distant future, and particularly in the direction of the greater release and more effective control of the energies and potentialities of man (and of other living things at will). In recent years the investigations and deductions of the psychiatrists, endocrinologists, and psychobiologists have thrown a beginning glimmer of real light upon the underlying biological bases of the activities and conduct of living things, and especially of man. We are beginning to understand in some detail and particularity how, conduct, normal and abnormal, moral and immoral, is the expression of "animal drives" or urges—themselves resultants of subtle chemical and physiological changes in the body—rather than of either free will or terrestrial and heavenly precepts. It does not seem extravagant to expect that as this understanding broadens and deepens ways may be found to bring it about that men will act somewhat more intelligently and less harmfully in politics, business, society, religion, and elsewhere generally, than they sometimes have in the past. The ever widening and deepening flow of biological knowledge is plainly furnishing a solid, scientific groundwork for a philosophy of life based on releases, in contradistinction to the philosophy of life based upon inhibitions and prohibitions that has so long held us enthralled. I am not unaware that current political philosophies in various parts of the world look backward in this regard, and insist on more prohibitions and regimentations. But they are going against biology, and if I read the history of evolution aright, biology will win. Nature is never in a hurry. And that odd bird the Blue Eagle was much shorter lived than even the poorest dinosaur.

This current trend of biology of which we have just been speaking has many different aspects. There are some who will recall the widespread interest and discussion stirred up many years ago by an essay of the late William James entitled *The energies of men*. It dealt with the release of normally untapped and unsuspected potentialities of men under certain conditions, sometimes those of shock and stress, sometimes under the impulsion of the will. Examples were given of men who, though enfeebled by poor health, performed feats of strength and endurance that would tax the finest athlete, when they encountered conditions that imperatively demanded such a performance.

We are working in the laboratory on another angle of the same general problem. We have experimented with seedlings, grown under very exactly controlled conditions such that all the matter and energy for growth and living (save for water and oxygen) come from the nutri-

tive materials stored in the cotyledons of the seed planted, which themselves are an integral part of the plant. Under these experimental conditions the seedling goes through a complete life cycle of germination, growth, adulthood, senescence, and eventual death. This life cycle corresponds quantitatively very closely to the normal life cycle of the plant in the field, except that it is greatly compressed and fore-shortened in time. By appropriate aseptic surgical procedures we have removed carefully measured parts of the food resources stored in the cotyledons of the cantaloup seeds we have used, and then observed the relative performance of such mutilated seedlings as compared with the normal controls, in respect of growth and duration of life. The net result is to demonstrate that the mutilated plants grow much larger and live many times longer, as compared with the normal controls, than they would be expected to in proportion to the amount of matter and energy for living available to them after the operation. The results indicated clearly that the operated seedlings utilized their available food resources much more effectively than the normal plant does. It is as though an inhibitor had been removed from the plant, freeing its potentialities for more adequate expression.

The possibilities suggested by these experiments seem far-reaching, though admittedly the exploration of the field has only just begun. Work in this direction on plants and lower animals may result in such an understanding of the physiology of releasing normally inhibited biological potentialities as to enable man to unleash effectively and usefully more of his own energies.

In the field of human biology the admitted and crying need is for adequate synthesis of existing knowledge. It is an obvious truism that we know more in detail about the biology of man than about that of any other organism. Anatomists, physiologists, anthropologists, psychologists, sociologists, and economists, have by analytical methods piled up a body of detailed information about man that is literally colossal. But what does it *mean* for humanity? Every thoughtful person will admit that there is a kind of moral necessity to go forward in the attempt to get a better and more comprehensive understanding of the whole nature of man. The material, mechanized civilization he has evolved may easily become a monster to destroy him unless he learns better to comprehend, develop, and control his biological nature. If inventions and discoveries cannot be intelligently managed after they are made, they are likely to be a curse rather than a blessing.

The bulk of scientific effort is, and always has been, directed to-

wards analysis unaccompanied by synthesis. Scientific men have mainly left it to philosophers and literary men to be the synthesizers of their data, shirking the task themselves with a few notable exceptions, of whom perhaps the greatest was a biologist, Charles Darwin. But analysis at best leads only to knowledge; while synthesis may furnish wisdom. And mankind sorely needs more wisdom right here and now!

PHARMACOLOGY.—*The toxicity for sheep of water solutions of hydrocyanic acid and the effectiveness of the nitrite-thiosulphate combination as a remedy.*[1] JAMES F. COUCH, A. B. CLAWSON and H. BUNYEA, Bureau of Animal Industry.

The results of a considerable number of experiments in which solutions of potassium cyanide were administered to sheep have previously been reported.[2,3,4] The potassium cyanide was administered as a drench and the quantity given in each base recorded as milligrams per kilogram of animal weight. In these experiments information was obtained concerning the smallest quantity of potassium cyanide that will produce symptoms in sheep, the smallest quantity that will kill and also concerning the effectiveness of a combination of sodium nitrite and sodium thiosulphate as a remedy for animals poisoned by potassium cyanide.

In the present paper data are presented concerning the toxicity for sheep of hydrocyanic acid in water solution and the remedial effectiveness of the nitrite-thiosulphate combination.

The solution of hydrocyanic acid used was prepared by mixing cold solutions of the calculated quantities of potassium cyanide and of tartaric acid in water and filtering off the precipitated potassium acid tartrate which was washed with a little cold water. The filtrate and washings were combined and diluted to a definite volume. The cyanide content of the solution was then determined by titration with N/10 silver nitrate solution and the strength was adjusted so that one cubic centimeter of solution contained 15.5 mg. of hydrocyanic acid. The solution contained less than 0.05 per cent of dissolved potassium acid tartrate which, in the doses given, was negligible.

A fresh solution was made each morning before experimental work, although analysis showed that there was no appreciable change in the strength of the solution when preserved for 72 hours in a cold place.

[1] Received February 28, 1935.
[2] This JOURNAL **24**: 369–395. 1934.
[3] This JOURNAL **24**: 528–532. 1934.
[4] This JOURNAL **25**: 57–59. 1935.

TOXIC AND LETHAL QUANTITIES

In all, 29 experiments were made on 20 sheep. In 17 of these no remedies were administered, the experiments being made primarily to determine the effects of various quantities of hydrocyanic acid as compared with those produced by potassium cyanide. The general results obtained in the 17 cases are shown in table 1.

TABLE 1.—Quantities of Hydrocyanic Acid Given to Sheep and the Effects Produced when no Remedies Were Used

Date 1935	Sheep		Quantities[a] given mg./kg. and effect			
	No.	Weight kg.	Symptoms	Sickness	Death	Remarks
Jan.						
14	1451	34.47			3.38	
14	1462	38.55			3.10	
14	1460	41.72			2.75	
14	1461	43.54			2.74	
14	1463	38.55			2.65	
14	1459	43.99			2.64	
14	1465	33.11			2.63	
14	1452	49.89			2.55	
14	1458	41.72			2.41	
16	1456	35.37			2.32	
18	1474	37.64		2.31		A very poor sheep
14	1464	48.98			2.29	
14	1457	34.92	2.27			
14	1454	46.49		2.03		
14	1453	36.73		1.71		
14	1455	30.84	1.36			
14	1456	35.37	1.05			Very slight effect

[a] The quantities are given as milligrams of hydrocyanic acid per kilogram of animal weight.

The effects produced on sheep 1456 by 1.05 mg. per kg. of animal weight were so mild that the quantity for this animal was apparently very close to the minimum toxic dose. The fact that 2.29 mg. killed while 2.27 mg. produced only symptoms indicates that 2.29 mg. is the approximate minimum lethal dose for sheep. That 2.31 mg. did not kill sheep 1474, a very poor, underweight animal, is not considered as valid evidence against this conclusion. Were the dosage for this animal based on its normal weight when in good flesh, it would be much lower than the figure considered as the minimum lethal dose.

To compare, on a common basis, the toxicity of hydrocyanic acid with that of potassium cyanide, the dosages of the two substances may be reduced to the cyanide (CN) equivalents. On this basis the toxic and lethal doses of cyanide in the two forms are essentially the same.

Following the administration of hydrocyanic acid in 29 cases, symptoms appeared in from 20 seconds to 2 minutes, the average time being 50 seconds. The time to prostration or collapse varied more widely, it being 50 seconds in the shortest case and 51½ minutes in the longest. The longest period was with a sheep given slightly more than 1 m.l.d. Twenty-three cases had an average time of 5 minutes 52 seconds. In the average the animals given the larger quantities showed symptoms and collapsed in a shorter time than those given the smaller doses.

The average time to symptoms in the sheep given 3 to 4 lethal doses was 42 seconds; with those given 1 to 1.5 lethal quantities, it was 55 seconds; and with sheep given toxic but sub-lethal doses, 56 seconds.

The average period to collapse in those sheep given from 3 to 4 lethal quantities was 1 minute 31 seconds, while with those given less than 1.5 minimum lethal doses it was 9 minutes 13 seconds. The longer average was due in part, but not entirely, to the inclusion of two resistant and somewhat unusual cases.

Of the sheep which received no remedy, 11 died. The time between the drenching with cyanide and death varied between 12.5 minutes and 1 hour 22 minutes, and averaged 37 minutes 50 seconds.

RESULTS OF THE ADMINISTRATION OF THE REMEDY

To test the effectiveness of the nitrite-thiosulphate combination as a remedy in cases of poisoning by hydrocyanic acid, 12 experiments were made on 10 sheep. For experimental use a water solution containing 1 gram of sodium nitrite and 2 grams of sodium thiosulphate per 15 c.c. of solution was prepared. Based on 2.29 mg. per kg. as the minimum lethal dose, these animals were given doses of hydrocyanic acid ranging from 3 m.l.d. to 4.0 m.l.d. In periods varying from 0.8 to 4 minutes after being drenched with the cyanide they were then injected intraperitoneally with 15 c.c. of a solution of the nitrite-thiosulphate combination as a remedy.

The results of the administration of the nitrite-thiosulphate combination are shown in table 2.

In 10 cases the remedy was given after the animals had collapsed. Of these, six (or 60 per cent) recovered. One sheep was given the remedy as soon as symptoms were apparent and before collapse, and one was treated at the time of collapse. Both died.

TABLE 2.—Showing the Effects of the Nitrite-thiosulphate Combination Administered Intraperitoneally as a Remedy for Sheep Poisoned by Hydrocyanic Acid

Date 1935	Sheep		Dose m.l.d.	Time from drench—			Effect
	No.	Weight kg.		To first symptom	To collapse	To giving remedy	
					Minutes		
Jan.							
16	1457	34.92	3.	0.5	1.3	1.8	Recovery
14	1469	43.99	3.	1.0	1.5	2.	do
16	1470	43.54	3.	1.0	1.8	2.7	Death
17	1466	35.83	3.1	.5	1.3	1.75	do
17	1469	43.99	3.25	.8	1.5	2.5	Recovery
17	1473	40.82	3.25	.75	1.75	2.	Death
17	1457	34.92	3.25	.5	2.2	4.	Recovery
17	1453	36.73	3.50	.7	1.	1.5	do
17	1455	30.84	3.50	.7	1.75	2.	Death
17	1454	46.49	3.75	.75	2.	2.	do
17	1474	37.64	4.	.5	1.	1.5	Recovery
17	1475	40.82	4.	.8 ±	1.8	.8	Death

For the sake of comparison with the results obtained using the same remedy for sheep poisoned by potassium cyanide as given in a former paper,[5] table 3 is included. This is a summary of table 2. In it the doses of hydrocyanic acid are arranged in classes, and the number of survivals and deaths in each class shown.

TABLE 3.—Effectiveness of the Remedy Against Varying Quantities of Hydrocyanic Acid

Dose of HCN m.l.d.	Number of animals	Number that survived	Number that died	Per cent survived
3	4	2	2	50
3.25	3	2	1	67
3.5	2	1	1	50
3.75	1		1	0
4	2	1	1	50
Total	12	6	6	50

From table 3 it will be noted that the remedy was 50 per cent effective against as much as 4 minimum lethal doses of hydrocyanic acid. When compared with the results obtained with sheep poisoned by potassium cyanide, in which 2.75 m.l.d. was the largest dose against which protection was secured in 50 per cent or more of the cases,[6] it would appear that the remedy is more effective against poisoning by hydrocyanic acid itself than against poisoning by potassium cyanide.

[5] This Journal **24**: 369–395. 1934.
[6] This Journal **24**: 369–395. 1934.

SUMMARY

When administered in sheep in a drench the minimum toxic dose of pure hydrocyanic acid is shown to be approximately 1.05 mg. per kg. of animal weight, and the minimum lethal dose is approximately 2.29 mg. per kg. When compared on a cyanide (CN) basis the differences in toxicity between hydrocyanic acid and potassium cyanide are slight and well within the limits of experimental error.

Following the administration of pure hydrocyanic acid, symptoms appear in an average of 50 seconds. The time to collapse is very variable. In the cases here reported the average time was 5 minutes 52 seconds. When no remedy was given the average time to death was nearly 38 minutes.

The nitrite-thiosulphate combination was 50 per cent effective as a remedy against from 3 to 4 m.l.d., and when injected intraperitoneally within 4 minutes after the hydrocyanic acid was administered.

GEOLOGY.—*Notes on the structure of the Erin shale of Alabama.*[1] C. F. Park, Jr., U. S. Geological Survey. (Communicated by W. W. Rubey.)

ABSTRACT

The Erin shale of east-central Alabama has previously been mapped as a stratigraphic unit in the Talladega slate. Fossils found in the Erin shale have been the basis for assigning a Carboniferous age to part or all of the Talladega slate and other crystalline rocks in the eastern part of the State. Evidence is presented to show that the contact between the Erin shale and the Talladega formation is a thrust fault dipping at a low angle eastward. The Erin shale is exposed by erosion through the overthrust block.

The type locality of the Erin shale of east-central Alabama is an area about 6 miles long and less than 1 mile wide. The exposure is in the valley of Talladega Creek along the east base of the Talladega Mountains in Clay County, Ala., about 8 miles northwest of Ashland. The Hillabee chlorite schist and the Ashland mica schist lie east of the Talladega formation (fig. 1). The Wedowee formation is east of the Ashland schist but is not shown on the map.

The Erin shale was described in 1903 by E. A. Smith, who considered it a lenticular mass in the Talladega slate, which he called "Ocoee."[2] Fossil plants were collected by Dr. Smith from the Erin shale and were determined by David White to be of Carboniferous age. Practically all papers treating of the Talladega slate that have appeared since 1903 have assigned a Carboniferous age to at least

[1] Published by permission of the Director, U. S. Geological Survey. Received March 30, 1935.

[2] Smith, E. A. Science, new ser., 18: 244–246. 1903.

part of the formation, on the assumption that the Erin shale is stratigraphically enclosed in the Talladega. As a result of study of the relations between the Talladega formation and the crystalline rocks to the east (the Hillabee schist, the Ashland schist, and the Wedowee formation) the several crystalline formations have been assigned to periods ranging from pre-Cambrian to Carboniferous.[3]

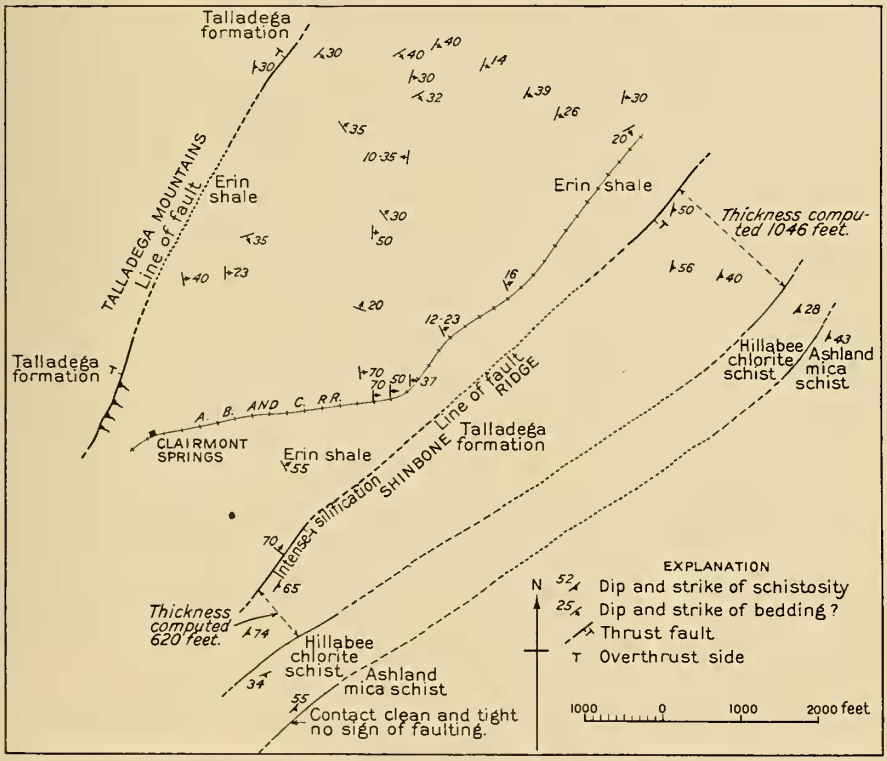

Fig. 1.—Sketch map of part of the Erin shale, showing relation to the Talladega formation.

Slightly altered Erin shale is exposed in numerous cuts along the Atlanta, Birmingham & Coast Railroad. This shale is a fine-grained black material that in thin sections shows a few small grains and bands of fine quartz in a carbonaceous matrix. Nothing is seen that would indicate that the rock had been metamorphosed except the

[3] PROUTY, W. F. *Geology and mineral resources of Clay County, Ala.* Alabama Geol. Survey County Rept. **1**: 38–41, 61–63. 1923; *Age of Talladega slates of Alabama.* Pan-Am. Geologist. **37**, n. 5: 363–366. 1922.

ADAMS, G. I. *Geology of Alabama.* Alabama Geol. Survey Special Rept. **14**: 30, 33, 36–39. 1926.

BUTTS, CHARLES, idem, 59–61, 217–219.

BROWN, J. A., *Graphite deposits of Ashland, Ala.* Econ. Geology. **20**: 208–229. 1925.

shale parting planes; no evidence of recrystallization is found. The Talladega formation is, by contrast, a thinly laminated schist composed almost entirely of sericite and quartz with a little chlorite; it is much more intensely metamorphosed than the Erin shale and appears to be almost entirely recrystallized. Both the Erin shale and the Talladega formation weather to a white or buff clay, but the outcrops of weathered Talladega schist generally contain some partly altered mica. The fact that the Erin shale weathers white or buff indicates that the carbon present has not been fixed as graphite. Graphite is a common constituent of the Ashland and Wedowee schists and is known to occur in the Talladega formation. West of the Erin shale the Talladega formation contains beds of quartzite and conglomerate in addition to the schist.

There is a discordance in strike between the cleavage in the Erin shale and the schistosity in the Talladega formation, locally amounting to nearly 90°. The Talladega formation just east of the eastern contact with the Erin shale is intensely silicified and rises in a cliff that in places is about 30 feet high. The Talladega formation is wedge-shaped in outcrop; near the northeastern border of the area mapped its thickness is about 1,000 feet and near the southwestern border, about 600 feet. This wedge-shaped block has been explained by Adams as the result of a thrust fault between the Talladega formation and the Ashland mica schist to the east. The Hillabee schist is considered to be a basic rock intruded along this thrust plane.[4] The schistosity in the Talladega is approximately parallel with that in the Hillabee and Ashland schists, but the strikes in the Talladega and the Erin are divergent.

It has been stated by Charles Butts that C. W. Hayes considered the Erin shale to be an infolded bed in the Talladega slate. Butts' notes, however, indicate a fault along the southeast contact of the Erin shale and the Talladega slate, but he states that Hayes' interpretation seems equally probable.[5] C. W. Hayes and David White concluded, after field study, that the Erin shales were unconformable with the Talladega slates.[6] Miss Jonas has recently described and mapped the Erin shale as a fenster in the Talladega slate but does not discuss it in detail.[7]

[4] Adams, G. I. op. cit., p. 38.

[5] Butts, Charles. Personal communication, January, 1935.

[6] McCaskey, H. D. *Some gold deposits of Alabama.* U. S. Geol. Survey Bull. 340: 38. 1908.

[7] Jonas, A. I. *Structure of the metamorphic belt of the Southern Appalachians.* Am. Jour. Sci. 24: 243. 1932. Geological map of the United States, southeastern quarter. U. S. Geological Survey, 1934.

There is sufficient evidence to indicate a fault between the Talladega formation and the Erin shale in this area. The evidence also justifies the suggestion that the Talladega formation has been thrust over the Erin shale along a fault plane that dips slightly eastward (3°–5° as determined by differences in altitude along the contracts). The Erin shale is thought to have been exposed by erosion of the thin overthrust plate, thus forming a window. The faulting along the line of outcrop of the Hillabee schist is considered a complementary thrust fault in the overthrust block. The mineralization along the fault in the Hillabee schist is therefore thought to be post-Erin shale. The assignment of part of the Talladega slate and other crystalline rocks in eastern Alabama to an age as recent as the Carboniferous, on the supposition that the Erin shale is a lenticular mass originally deposited in the Talladega, is believed to be unwarranted by the field relations here described.

ENTOMOLOGY.—*Three new reared parasitic Hymenoptera, with some notes on synonymy.*[1] C. F. W. MUESEBECK, Bureau of Entomology and Plant Quarantine. (Communicated by HAROLD MORRISON.)

The new species described below have been reared in the course of studies in economic entomology. In order to make the names available for use the descriptions are published at this time.

SERPHOIDEA

SCELIONIDAE

Telenomus catalpae, new species

In the female sex very similar to *sphingis* Ashmead, but distinguished by having the occipital carina only very narrowly interrupted at the middle, by the yellowish mouth region, and by the somewhat stouter thorax. In the male sex at once distinguished from all related species by the entirely reddish-yellow head and thorax.

Female.—Length, 1 mm. Head transverse, more than twice as broad as long; viewed from in front much broader than long; eyes finely hairy, rather strongly divergent below; frons smooth, delicately reticulated laterally below middle of eyes; malar space half as long as scape; vertex finely reticulate, punctate and subopaque; ocelli in a low triangle, the lateral ones touching the eyes; temples flat, polished except for a narrow reticulated border along the eyes; antennae 11-segmented; scape not reaching summit of vertex; pedicel at least one-third as long as scape; first segment of funicle distinctly a little shorter than pedicel; second and third segments of funicle subequal, shorter than first and barely or not longer than broad; fourth shorter than second or third and about as wide as these; fifth to ninth seg-

[1] Received March 20, 1935.

ments forming a distinct club, the fifth much the smallest, strongly transverse and somewhat narrower than the following; sixth, seventh and eighth subequal, distinctly somewhat broader than long, the apical segment conical.

Thorax narrower than head; mesoscutum evenly convex, minutely reticulate punctate, finely hairy and subopaque; scutellum smooth and polished; metanotum finely sculptured and opaque at the middle; propodeum with a prominent oblique carina on each side from near middle of base of propodeum to a point beyond middle of lateral margin; stigmal vein more than twice as long as marginal and about half as long as postmarginal; submarginal vein with about 10 long setae.

Abdomen hardly shorter than thorax and nearly as broad, more or less truncate at apex; first tergite four times as broad as long at the middle, smooth and polished except for a row of elongate pits bordering the basal margin; second tergite about one and one-half times as long as broad, smooth and polished except for a row of foveae at the base and a few weak short striulae medially at base; remaining tergites very short; ovipositor sheath slightly exserted.

Black; mandibles, clypeus, and a spot between bases of antennae yellowish; scape black, pale at apex; remainder of antenna dark brown; all coxae and femora blackish; anterior tibiae pale, the middle and posterior pairs more or less infuscated; tarsi brownish yellow, the apical segment black; wings hyaline.

Male.—Essentially like the female except in the structure of the antennae and in color. Antennae 12-segmented; pedicel and basal three flagellar segments subequal, slightly longer than broad, fourth to ninth flagellar segments shorter, moniliform; the apical segment conical. Reddish yellow; antennae and legs a little paler; apical half of abdomen more or less blackish.

Type locality.—Takoma Park, Md.

Type.—U. S. National Museum No. 50795.

Host.—Eggs of *Ceratomia catalpae* Bdv.

Described from 32 females and 51 males (type, allotype, and paratypes) reared by J. W. Bulger at the type locality September 27, 1932; and 2 females and 3 males, likewise reared from eggs of *C. catalpae*, by W. J. Baerg, August 5, 1933, at Fayetteville, Ark.

ICHNEUMONOIDEA

Braconidae

Apanteles epiblemae, new species

This species is exceedingly similar to *epinotiae* Viereck, with which it is easily confused. It may be distinguished from that species, however, by its complete and strong propodeal costulae, by its relatively longer intercubitus, by its more definitely punctate face, mesoscutum, and mesopleurum, by the prominence of the posterior lateral angles of the propodeum, and by its longer ovipositor.

Female.—Length, 2.5 mm. Head strongly transverse, temples narrow; face flat, definitely closely punctate and subopaque; malar space equal to basal width of mandible; eyes long; vertex minutely punctate, opaque; ocellocular line and postocellar line subequal, twice the diameter of an ocellus, antennae slightly shorter than body.

Thorax, stout, broader than head; mesoscutum finely confluently punctate, minutely longitudinally rugulose posteriorly; disk of scutellum longer than broad at base, smooth and polished; polished areas on lateral face of

scutellum very large, triangular, extending nearly to the base; propodeum finely rugulose, with a large, sharply margined median areola which is open at the base and is traversed by several low transverse rugae, and with strong, complete costulae; posterior lateral angles of propodeum very prominent; mesopleurum anteriorly confluently punctate and opaque; first abscissa of radius about one and one-half times as long as transverse cubitus; metacarpus distinctly longer than stigma; nervellus strongly curved; posterior coxae smooth; inner calcarium of posterior tibia hardly half as long as basitarsus.

Abdomen a little narrower than thorax; first tergite considerably longer than broad, nearly parallel sided, truncate at apex, closely rugulose; plate of second tergite strongly transverse, longest at the middle, its median length about one-fourth its apical width, very weakly, indefinitely sculptured; third and following tergites polished, the third much longer than the second; ovipositor sheath slender, fully as long as the abdomen and as long as posterior tarsus.

Black; palpi pale; anterior legs beyond trochanters testaceous; middle femora apically, middle tibiae and posterior tibiae, except at apex, and middle tarsi, except apical segment, reddish-yellow; tegulae yellowish-white; wings whitish hyaline; stigma hyaline margined with brown; veins mostly hyaline; costa whitish; metacarpus brown.

Male.—Like the female in all essential respects; however, the second tergite is smoother, the legs, especially the middle and posterior tibiae, are darker; and the antennae are longer than the body.

Type locality.—Meade County, Kans.

Type.—U. S. National Museum No. 50796.

Host.—*Epiplema strenuana* Walker.

Described from 7 females and 6 males. The type, allotype, and one male and one female paratype reared in February 1933 from the above-named host at the type locality by Sam G. Kelly; three males and one female from Clark County, Kans., likewise reared by Mr. Kelly in February 1933; one male from Riley County, Kans., and one female from Manhattan, Kans., reared by Mr. Kelly in August 1933; one female from Bridgeville, Del., reared from *E. strenuana* by A. O. Baker, August 10, 1933; one female reared from the same host by William Rau Haden at Camden, Del., August 14, 1933; and one female reared from *Grapholitha molesta* Busck by O. I. Snapp, of the Bureau of Entomology and Plant Quarantine, at Fort Valley, Ga., June 16, 1925, under Quaintance No. 21938. In the female paratypes the color of the legs ranges from almost entirely testaceous beyond trochanters to mostly black.

Apanteles thujae, new species

In my key to the Nearctic species of *Apanteles*[2] this species runs directly to *monticola* Ashmead, which it very closely resembles. It may be distinguished from that species, however, by its somewhat depressed thorax, shorter malar space, punctate scutellum, and the rugulose punctate, rather than more or less striate, sculpture of the basal two abdominal tergites.

Female.—Length, 1.8 mm. Head slightly narrower than thorax; eyes a little convergent below; malar space shorter than basal width of mandible; face smooth and shining, with only indistinct setiferous punctures; temples narrow but convex; ocell-ocular line twice diameter of an ocellus; antennae about as long as body.

[2] Proc. U. S. Nat. Mus. **58**: 487. 1920.

Thorax stout, distinctly somewhat depressed; mesoscutum broader than long, opaque, evenly, minutely, and shallowly punctate; suture at base of scutellum very narrow, minutely foveolate; scutellum flat, subopaque, sculptured like mesoscutum though more weakly; propodeum convex, more than twice as broad as long, without a median areola, smooth and shining, with only a little weak rugulosity along posterior margin; mesopleurum smooth and polished except anteriorly, where there are some shallow punctures; inner calcarium of posterior tibia not longer than outer and not quite half as long as metatarsus; stigma slightly shorter than metacarpus; radius issuing from middle of stigma, perpendicular to anterior margin of wing and slightly longer than intercubitus.

Abdomen narrower than thorax; chitinized plate of first tergite narrowing a little toward apex, twice as long as broad at apex, gently excavated at base, where it is smooth and polished, the apical two-thirds finely rugulose punctate, and with a more or less distinct, though very narrow and shallow, median longitudinal groove on posterior half; lateral membranous margins of first tergite very broad on apical half; plate of second tergite strongly transverse, more than three times as broad on posterior margin as long, defined laterally by indistinct oblique grooves, more weakly sculptured than first tergite, its posterior margin straight; following tergites smooth and shining; ovipositor sheath at least as long as posterior femur but hardly as long as posterior tibia, rather strongly broadened toward apex; ovipositor a little decurved at apex.

Black; antennae entirely black, also tegulae; apex of anterior femur, more or less of anterior tibia, the anterior and middle tarsi, and posterior tibia at extreme base, yellowish brown; calcaria of tibiae whitish; wings clear hyaline, stigma and veins brown.

Male.—Essentially like female, but having antennae considerably longer than body.

Type locality.—Bar Harbor, Maine.

Type.—U. S. National Museum No. 50797.

Host.—*Recurvaria thujaella* Kearfott.

Described from seventeen females and one male (Type, allotype, and 16 paratypes) reared by A. E. Brower at type locality July 15–19, 1933, and two females, likewise reared by Dr. Brower, July 8, 1933, at Mt. Desert Island, Maine.

(*Macrocentrus laspeyresiae* Mues.) = *Macrocentrus instabilis* Mues.

Macrocentrus instabilis Muesebeck, Proc. U. S. Nat. Mus. **80**: 34. 1932.
Macrocentrus laspeyresiae Muesebeck, loc. cit., p. 37 (new synonymy).

Since the publication of the paper in which *instabilis* and *laspeyresiae* were described I have seen a large number of additional specimens, reared from *Grapholitha molesta* Busck and *Carpocapsa pomonella* L. This material exhibits complete intergradations between typical *instabilis* and typical *laspeyresiae*, and has convinced me that the two are merely variants of an extremely variable species.

(*Aneurobracon* Brues) = *Mesocoelus* Schulz

Coelothorax Ashmead (not *Coelothorax* Anceys). Proc. Ent. Soc. Wash. **4**: 165. 1898.

Mesocoelus Schulz, Zool. Ann. 4: 88. 1911.

Aneurobracon Brues, The African Republic of Liberia and the Belgian Congo, based on the Harvard African Expedition, 2: 1002 (new synonymy).

Mesocoelus Muesebeck, Proc. Biol. Soc. Wash. 45: 227. 1932.

At the time of my brief discussion of this genus I had not seen the paper by Brues in which *Aneurobracon* was described. His description and figures leave no doubt that the genotypic species, *Aneurobracon bequaerti*, is congeneric with the genotype of *Mesocoelus*. It appears to be very similar to *philippinensis* Mues., but differs in the complete absence of a medius and the slightly longer antennae.

ENTOLOMOGY.—*An undescribed rubber tingitid from Brazil (Hemiptera).*[1] C. J. Drake and M. E. Poor, Iowa State College. (Communicated by Harold Morrison.)

Through the kindness of Mr. H. G. Barber of the U. S. Bureau of Entomology, the writers have received a series of 40 specimens of an undescribed species of lace bug from Brazil. The insect was taken in large numbers on the leaves of the rubber tree, *Hevea braziliensis* Muell. Arg.

Leptopharsa heveae, sp. nov. Fig. 1.

Elongate, moderately broad, whitish. Antennae very long, dark brown to brownish black, clothed with numerous fine, short, pale hairs; segment I long, moderately stout, almost straight, nearly six times as long as II, the latter very short; III very long, slender, nearly straight, two and a half times the length of one; IV very long, slender, scarcely stouter than three, clothed with longer hairs, one and one-half times the length of one. Head brown, largely covered with whitish exudation, armed with five long, pale testaceous spines; frontal spines sub-porrect, blunt, the tips contiguous; median and lateral spines more or less resting on the surface of the head. Bucculae whitish, reticulate, closed in front. Rostral laminae widely separated on meso- and metanotum; rostrum extending on the basal portion of mesosternum. Orifice distinct.

Body beneath ferrugineous, more or less covered with whitish exudation. Legs long, slender, testaceous, the tarsi darker. Pronotum moderately tumid, deeply and closely pitted, reticulate on triangular portion, tricarinate; median carina thicker and more strongly elevated, without distinct areolae; lateral carinae distinct, sub-parallel, faintly converging posteriorly. Paranota moderately broad, biseriate, moderately reflexed, the lateral margin rounded and finely serrate. Collum distinct, raised at the middle, reticulate. Calli black, often covered with white exudation. Elytra widening posteriorly, finely serrate along the costal margin, extending considerably beyond tip of abdomen, the areolae not very large and clear; costal area broad, mostly quadriseriate, with five rows at widest part, the areolae not arranged in very regular rows; subcostal area narrow, biseriate; discoidal area moderately

[1] Received March 22, 1935.

large, faintly impressed, not quite reaching middle of elytra, narrowed at apex, with five to six rows of areolae at widest part; sutural area rather widely reticulated. Wings subequal to abdomen in length.

Length, 4.00–4.20 mm.; width, 1.35–1.50 mm.

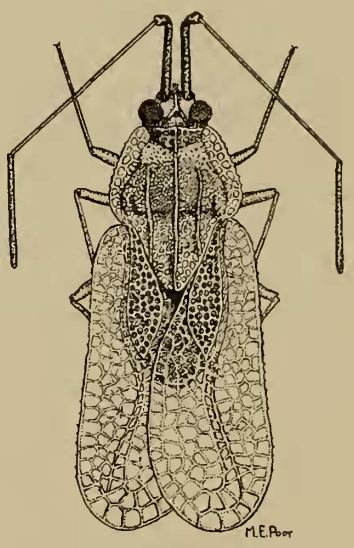

Fig. 1.—*Leptopharsa heveae* sp. nov., *type*, ♂.

Holotype, male, and allotype, female, Boa Vista Rio Tapajo, Brazil, on leaves of rubber tree, collected by Dr. C. H. T. Townsend. Paratypes, taken with type and from Para, Brazil, on rubber tree, taken by H. W. Moore. Types in U. S. National Museum.

This is the first record of a tingitid pest of the rubber plant. It is a very distinct species and probably most closely allied to *L. abella* Drake from Brazil. From the latter or other closely allied forms, *L. heveae* may be distinguished by its larger size, white color and wider costal area. The genus *Leptopharsa* Stål contains about 70 described species, largely from tropical America.

BOTANY.—*The genus* Cremosperma.[1] C. V. Morton, National Museum. (Communicated by William R. Maxon.)

Bentham's genus *Cremosperma* has always been considered as doubtfully valid. Thus, Hanstein in his monograph of the family Gesneriaceae[2] listed it among the dubious genera; Bentham and Hooker[3] reduced it to a section of *Besleria;* and Fritsch,[4] although he

[1] Published by permission of the Secretary of the Smithsonian Institution. Received March 11, 1935.

[2] Linnaea **34**: 429. 1865.

had seen no specimens, listed it a doubtful genus related to *Besleria*. Very recently Fritsch[5] has described as new *Besleria* (*Cremosperma*) *cinnabarina*, reducing the genus to *Besleria* outright.

For some time I have been engaged in a monographic study of *Besleria* and have had an opportunity to examine most of the species. During this investigation I came across numerous specimens of *Cremosperma*, which had been variously identified as belonging to the genera *Besleria*, *Episcia*, *Achimenes*, *Tydaea*, and *Koellikeria*, all of which (with the exception of *Besleria*) are quite remotely related. These specimens, all from the Andes of Colombia and Ecuador, were distinguished by a low herbaceous habit and a distinctive racemose-capitate inflorescence, and were obviously congeneric with Bentham's *Cremosperma hirsutissimum*.

Further study has convinced me that *Cremosperma* represents a perfectly valid generic type, perhaps of not even very close affinity with *Besleria* in spite of the similar disk and anthers of both. In addition to a very different habit and inflorescence, the species of *Cremosperma* all have small, usually pale-colored corollas with widely flaring limb and usually non-ventricose tube. The usually highly colored corollas of *Besleria* have a small inconspicuous limb except in the two species belonging to the subgenus *Macrobesleria*, in which the corolla lobes are larger and patent; in these two species, however, the corolla tube is markedly ventricose and the plants are otherwise very different from *Cremosperma*. The calyx also differs from that of any species of *Besleria*, being turbinate or cylindric-turbinate with short equal lobes and ten conspicuous costae, these in a few species sometimes obscured by the dense pubescence. The fruits of *Cremosperma* will apparently afford technical characters of importance also. Those of *Besleria* are fleshy berries with a thick skin. Bentham originally described those of *Cremosperma* as capsules opening by two valves, but an examination of the few mature fruits available indicates rather that they are capsules with thin membranous walls, not really two-valved but rupturing irregularly. I have not been able to study any mature seeds.

The number of species must now be increased from two to ten and there are indications that further exploration of Colombia will reveal still others. The species are apparently very local in distribution and many are known from a single collection only.

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[3] Genera Plantarum **2**: 1016. 1876.
[4] Engl. & Prantl. Pflanzenfam. 4[3b]: 159. 1895.
[5] Notizbl. Bot. Gart. Berlin **11**: 976. 1934.

Cremosperma Benth.[6]

Herbae perennes vel fruticuli perpusilli, caulibus erectis vel adscendentibus vel repentibus. Folia opposita vel quaternata, aequalia vel inaequalia, saepe ovata vel elliptica, interdum orbicularia vel oblanceolata, plerumque basi subcordata, saepe hirsuta, petiolata, paucinervata. Inflorescentia racemoso-capitata (vel raro flores solitarii?). Pedunculus communis brevis vel elongatus. Calyx tubulosus, turbinatus vel cylindrico-turbinatus, 10-costatus, lobis parvis, erectis, integris, acutis. Corolla alba, flava vel raro rubescens vel coccinea (?), parva, tubo cylindrico vel infundibuliformi, lobis magnis, patentibus, rotundatis. Stamina 4, didynama, loculis confluentibus. Annulus hypogynus annularis vel semi-annularis, glandulis discretis nullis. Ovarium glabrum. Capsula subglobosa, membranacea, irregulariter dehiscens.

TYPE SPECIES: *Cremosperma hirsutissimum* Benth.

KEY TO SPECIES

Flowers racemose-capitate on a common peduncle. Mostly lowland species.
- Leaves mostly borne in whorls of 3 or 4, equal, acute at base and apex.
  - Corolla white, the tube ampliate upwardly; calyx lobes deltoid. . . . . **1. C. pusillum.**
- Leaves opposite, never in whorls.
  - Leaves of a pair unequal, the smaller one much reduced, sometimes auriculiform; corolla tube hardly at all ampliate.
    - Larger leaves oblanceolate, acute at base, glabrate above; calyx lobes ovate-deltoid; disk reduced to a bilobed posterior gland. . . . . **2. C. congruens.**
    - Larger leaves obliquely oval, obliquely subcordate at base, densely sericeous-pilose above; calyx lobes linear-lanceolate; disk annular. . . . . **3. C. cotejense.**
  - Leaves of a pair equal, subcordate or rounded at base; corolla tube ampliate (except in *C. Castroanum*).
    - Calyx glabrous, except for the ciliate lobes, glaucous; common peduncle about 10 cm. long; corolla reddish, glabrous. . . . . **4. C. jucundum.**
    - Calyx hirsute or hirsutulous, not glaucous; common peduncle not more than 5 cm. long; corolla white or yellow, pilose.
      - Corolla 8–10 mm. long, yellow, the lobes 1.5–2 mm. long. Leaves ovate or elliptic, not tuberculate above.
        - Leaves glabrous above; calyx lobes deltoid, much shorter than the calyx tube. . . . . **5. C. ignotum.**
        - Leaves hirsute above; calyx lobes lanceolate, almost equaling the calyx tube. . . . . **6. C. Castroanum.**
      - Corolla 12–15 mm. long, the lobes 3–6 mm. long.
        - Calyx about 8.5 mm. long.
          - Leaves elongate-tuberculate above, about 4.5 cm. long; calyx lobes linear-lanceolate. . . . . **7. C. nobile.**

[6] Plant. Hartw. 234. 1846.

Leaves not tuberculate above, 7.5–8.5 cm. long; calyx lobes oblong.....**8. C. hirsutissimum.**

Calyx about 5.5 mm. long, the lobes ovate, broad. Leaves not tuberculate above, suborbicular, up to 6.2 cm. wide; corolla white.....**9. C. album.**

Flowers aggregate in the leaf axils, a common peduncle absent. Calyx deeply parted, the lobes lanceolate; corolla deep red. High mountain species. .....**10. C. cinnabarinum.**

1. **Cremosperma pusillum** Morton, sp. nov.

Frutex pusillus, usque ad 20 cm. altus; caules crassi, teretes, hirsuti, internodiis brevissimis, nodis perspicuis; folia ternata vel quaternata, aequalia, parva, lamina anguste elliptica, maxima ca. 20 mm. longa et 7 mm. lata, evidenter crenata, basi apiceque acuta, supra sparse hirsuta, saepe bullata, subtus reticulata, imprimis in nervis villosa (nervis secundariis 4 vel 5 jugis), petiolata, petiolo usque ad 15 mm. longo, hirsuto, gracili; pedunculus communis tenuis, usque ad 3 cm. longus, glaber vel sparse pilosus; flores racemoso-capitati, pauci, pedicellis usque ad 4 mm. longis, parce pilosis; calyx campanulatus, ca. 5 mm. longus, sparse pilosus, tubo 2.5–3 mm. longo, lobis deltoideis, obtusis; corolla alba, erecta, tubo cylindrico, ca. 11 mm. longo, ca. 2 mm. lato, sursum ampliato et ca. 4 mm. lato, extus glabro vel parce piloso, lobis magnis, ca. 5 mm. longis et 4 mm. latis, patentibus, rotundatis, utrinque glabris; ovarium glabrum; stylus glaber; discus tenuis, altus, uno latere interruptus; fructus deest.

Type in the Kew Herbarium, collected at Tambo de Savanilla, probably Province of Nariño, Colombia, Dec. 18, 1876, by E. André (no. 4572); duplicate in the New York Botanical Garden. A second collection of this species is *Kalbreyer* 1470, in the Kew Herbarium, collected in the Province of Antioquia, Colombia. This agrees in all particulars with the André specimens.

Easily distinguishable by its very small ternate or quaternate leaves, in contrast to strictly opposite leaves of the other species.

A somewhat larger specimen collected in Ecuador by Jameson appears varietally distinct:

var. **ecuadorense** Morton, var. nov.

Differt a var. *typica* foliis majoribus (usque ad 5.3 cm. longis et 2.7 cm. latis), magis hirsutis, calycibus longioribus (ca. 9 mm. longis) et disco annulari nec interrupto.

Type in the Kew Herbarium, collected on Mt. Pichincha, Ecuador, ca. 1,800 meters altitude, Jan. 21, 1856, by W. Jameson.

2. **Cremosperma congruens** Morton, sp. nov.

Herba parva, usque ad 15 cm. alta; caules teretes, strigosi, internodiis brevibus; folia opposita, cujusve paris saepe valde inaequalia, alterum lamina oblanceolata, usque ad 3.5 cm. longa et 1.4 cm. lata, apicem versus serrata, acuta, basi attenuata, supra primum parce pilosa, mox glabrata, subtus imprimis in nervis strigosa (nervis secundariis ca. 6 jugis), petiolata (petiolo brevi, usque ad 3 mm. longo, strigoso), alterum parvum vel auri-

culiforme, lanceolatum, integrum, vix petiolatum; pedunculus communis tenuis, usque ad 27 mm. longus, glaber vel parce pilosus; flores racemoso-capitati, pedicellis brevibus vel usque ad 7 mm. longis, pilosis; calyx turbinatus, 4.5 mm. longus, sericeo-strigosus, tubo 3.5–4 mm. longo, intus glabro, lobis ovato-deltoideis, obtusis; corollae tubus erectus, cylindricus, ca. 7 mm. longus et 1.5 mm. latus sursum non ampliatus, extus pilosus, lobis magnis, ca. 3 mm. longis et 2 mm. latis, patentibus, rotundatis; filamenta libera, glabra; antherae parvae, connatae; ovarium globossum, glabrum; stylus glaber; stigma capitatum; discus in glandulam posticam bilobam reductus.

Type in the U. S. National Herbarium, no. 1,185,005, collected at Paime, Department of Cundinamarca, Colombia, altitude about 1,000 meters, by Brother Ariste Joseph (no. A923). There is in the Hooker Herbarium at Kew another specimen of this species collected at the same locality by Goudot.

3. Cremosperma cotejense Morton, sp. nov.

Herba parva, usque ad 30 cm. alta; caules crassi, teretes, sparse pilosi; folia herbacea, cujusve paris valde inaequalia, alterum obliquc ovale, usque ad 6 cm. longum et 2.5 cm. latum, serratum, apice acutum, basi oblique subcordatum, supra dense pilosum, subtus imprimis in nervis pilosum (nervis secundariis ca. 4 jugis), petiolatum, petiolis gracilibus, usque 12 mm. longis, alterum auriculiforme, ca. 8 mm. longum, parum serratum, vix acutum, basi subcordatum, vix petiolatum; pedunculus communis usque ad 2.5 cm. longus gracilis, sparse pilosus; flores racemoso-capitati, pedicellis brevissimis, ca. 2 mm. longis, gracilibus, sparse pilosis; calycis tubus ca. 2 mm. longus, angustus, extus hirsutus, intus glaber, lobis lineari-lanceolatis, ca. 2 mm. longis, hirsutis; corollae tubus ca. 4 mm. longus, ca. 1 mm. latus, anguste cylindricus, sursum vix ampliatus, glaber, in calyce inclusus, lobis ca. 3 mm. longis, patentibus, albis, extus pilosis; antherae in fauce dispositae, connatae, parvae; filamenta glabra; ovarium glabrum; stylus glaber; discus annularis, integer, glaber; fructus deest.

Type in herbarium of the New York Botanical Garden, collected in dense, damp forests around Coteje on Rio Timbiqué, Province of Cauca, Colombia, altitude 100–500 meters, by F. C. Lehmann (no. 8888).

Lehmann's field note reads as follows: "Stems up to 30 cm. in length, poorly ramified, procumbent at base. Leaves soft herbaceous, black-green, on the upper side with a greasy sheen. Flowers white."

4. Cremosperma jucundum Morton, sp. nov.

Herba vix 15 cm. alta; caules crassi, teretes, lanati; folia opposita, fere aequalia, lamina ovata, usque ad 10 cm. longa et 6 cm. lata, membranacea, leviter crenata, apice rotundata, basi subcordata, supra hirsuta, paullulum bullata vel tuberculata, subtus imprimis in nervis lanata, nervis secundariis ca. 6 jugis; petiolus brevis, usque ad 7 mm. longus, crassus, dense hirsutus; pedunculus communis elongatus, usque ad 10 cm. longus, gracilis, hirsutus; flores racemosi-capitati, numerosi, pedicellis ca. 6 mm. longis, fere glabris, glaucescentibus, apice incrassatis; calyx campanulato-turbinatus, ca. 4.5 mm. longus, glaber, glaucus, lobis deltoideis, ciliatis; corolla rubescens, glabra, ca. 11 mm. longa, tubo cylindrico, sursum gradatim ampliato, non ventricoso, lobis magnis, patentibus, rotundatis; ovarium glabrum; discus annularis, integer, glaber.

Type in the Kew Herbarium, collected in the Province of Antioquia, Colombia, in 1879, by Kalbreyer (no. 1821). Kalbreyer's field note reads: "Herb in tufts; leaf blackish-green with velvety lustre; flowers in umbels, reddish. Forest shade, 2,700–3,000 feet."

5. Cremosperma ignotum Morton, sp. nov.

Herba parva, usque ad 9 cm. alta, caules perbreves, lanati; folia opposita, cujusve paris aequalia, elliptica, maxima 5.8 cm. longa et 3.2 (raro 3.8) cm. lata, membranacea, integra vel parum denticulata, apice acuta vel rotundata, basi subcordata, supra glabra, subtus imprimis in nervis appresso-pubescentia (nervis secundariis ca. 4 jugis), breviter petiolata, petiolo crasso, ca. 7 mm. longo, lanato; pedunculus communis tenuis, usque ad 4 cm. longus, fere glaber vel parce pilosus; flores racemoso-capitati, pedicellis brevibus vel usque ad 3.5 mm. longis, pilosis; calyx turbinatus, ca. 3.5 mm. longus, 10-costatus, imprimis in costis strigosus, tubo ca. 2.5 mm. longo, lobis ca. 1 mm. longis, deltoideis, acutis, paullulum inaequalibus; corolla flava, 8–10 mm. longa, extus parce pilosa, tubo cylindrico, fauce ampliato, lobis ca. 2 mm. longis, patentibus, rotundatis; antherae parvae, connatae; ovarium glabrum; discus annularis, altus, integer; fructus deest.

Type in the herbarium of the Academy of Natural Sciences, Philadelphia, no. 642,556, collected in forest along Rio Caballete, Santa Rosa, Dagua Valley, Department of El Valle, Colombia, altitude 200–300 meters, Sept. 22, 1922, by E. P. Killip (no. 11540). A duplicate is in the herbarium of the New York Botanical Garden.

6. Cremosperma Castroanum Morton, sp. nov.

Herba erecta, usque ad 20 cm. alta; caules crassi, teretes, dense hirsuti; folia opposita, aequalia, lamina ovata vel elliptica, usque ad 9.5 cm. longa et 6 cm. lata, membranacea, dentata, apice late obtusa vel rotundata, basi rotundata, supra hirsuta, plana, subtus pilosa, nervis secundariis ca. 5 jugis; petiolus usque ad 3 cm. longus, hirsutus; pedunculus communis usque ad 5 cm. longus, tenuis, pilosus; flores racemoso-capitati, numerosi, pedicellis brevissimis, 2–2.5 mm. longis, pilosis; calyx cylindrico-turbinatus, ca. 5 mm. longus, hirsutus, intus glaber, lobis lanceolatis, tubum fere aequantibus; corolla flava, parva (usque ad 8.5 mm. longa), sparse pilosa, tubo cylindrico, ca. 2 mm. lato, sursum vix ampliato, lobis semioblongis, 1.5 mm. longis, rotundatis, patentibus; filamenta tenuia, glabra; antherae parvae; ovarium glabrum, stylus glaber; stigma capitatum; discus annularis, brevis, integer, glaber.

Type in the U. S. National Herbarium, no. 1,517,374, collected at Tutunendo, 20 kilometers north of Quibdó, Intendencia de Chocó, Colombia, altitude 80 meters, May 19–20, 1931, by W. A. Archer (no. 2151). I have seen the following additional collections, all from the Intendencia de Chocó: *Triana* 2546; *R. B. White* s. n.; La Concepción, 15 kilometers east of Quibdó, *Archer* 1998, 1970.

Named in honor of Señor Rudolfo Castro, of Quibdó, who was of great assistance to Dr. Archer during his stay in Colombia.

Similar in aspect to *C. album* Morton, with which it grows, but easily distinguishable by its very small yellow corollas. The corolla tube is cylindric and hardly at all widened upwardly. The larger, white corollas of *C. album* have a markedly ampliate corolla tube and very wide throat.

7. Cremosperma nobile Morton, sp. nov.

Herba parva, vix 20 cm. alta; caules crassi, teretes, dense lanati; lamina foliorum ovata, maxima ca. 4.5 cm. longa et 3 cm. lata, plus minusve crassa, apice acuta, basi rotundata, perspicue crenata, supra hirsuta, elongato-tuberculata, subtus hirsuta, nervis secundariis 5–8 jugis; petiolus crassus, usque ad 2 cm. longus, dense lanatus; pedunculus communis crassus, brevis, ca. 12 mm. longus, dense lanatus; flores racemoso-capitati, pedicellis brevissimis, paucis, hirsutis; calycis tubus ca. 3.5 mm. longus, extus hirsutus, intus glaber, lobis lineari-lanceolatis, ca. 5 mm. longis, acuminatis, extus hirsutis; corollae tubus gracilis, ca. 8 mm. longus, anguste cylindricus, ca. 1 mm. latus, sursum gradatum ampliatus, ca. 1.5 mm. latus, glaber, lobis magnis, ca. 6 mm. longis, patentibus, extus pilosis; ovarium cylindricum, glabrum; discus annularis, integer, glaber; fructus deest.

Type in herbarium of the New York Botanical Garden, collected at Armada, Province of Nariño, Colombia, May 22, 1876, by E. André (no. K43).

A peculiar species by reason of the elongate-tuberculate upper surfaces of the leaves, in which respect it is analogous to *Besleria princeps* Hanst.

8. Cremosperma hirsutissimum Benth. Plant. Hartw. 234. 1846.

Founded on a Hartweg specimen collected in the Andes of Popayán, Colombia. This, the type species of the genus, has not since been recollected.

9. Cremosperma album Morton, sp. nov.

Herba repens, usque ad. 20 cm. alta; caules teretes, crassi, hirsuti; folia opposita, aequalia, lamina suborbiculari, maxima ca. 9 cm. longa et 6.2 cm. lata, membranacea, apice dentata vel subintegra, late rotundata, basi subcordata, supra hirsuta, subtus imprimis in nervis hirsuta, nervis secundariis ca. 5 jugis; petiolus crassus, hirsutus, usque ad 2.2 cm. longus; pedunculus communis usque ad 4 cm. longus, dense hirsutus; flores racemoso-capitati, numerosi, pedicellis brevibus, 1.5–3.5 mm. longis, hirsutis; calyx late turbinatus, ca. 5.5 mm. longus, hirsutus, lobis ovatis, latis; corolla alba, 12–15 mm. longa, pilosa, tubo basi cylindrico, ca. 2 mm. lato, sursum subito ampliato et 8 mm. lato, lobis magnis, ca. 3 mm. longis, patentibus, late rotundatis, ovarium glabrum; discus annularis, altus, irregulariter erosus, glaber.

Type in the herbarium of the Academy of Natural Sciences, Philadelphia, no. 642,503, collected at Córdoba, Dagua Valley, Department of El Valle, Colombia, altitude 80–100 meters, May 8, 1922, by E. P. Killip (no. 5242). Duplicates in the Gray Herbarium, the herbarium of the New York Botanical Garden, and the U. S. National Herbarium. An additional specimen was collected in the Intendencia de Chocó by Triana.

10. Cremosperma cinnabarinum (Fritsch) Morton, comb. nov.

Besleria (*Cremosperma*) *cinnabarina* Fritsch, Notizbl. Bot. Gart. Berlin.

11. 976. 1934.

Type collected in glades of dense forests in the Montaña de Caramanta, Dept. of El Valle, Colombia, August, 1891, altitude 2,300–2,600 meters, by F. C. Lehmann (no. 7441).

The present species, of which I have seen no material, may not be congeneric with those above described, the axillary flowers, as well as the corolla color, being anomalous. The habit also is apparently different, the stem being described as up to one meter long, whereas the stems of none of the other species exceed 30 cm. in length. Lehmann's note is as follows: "Weed with fleshy stems up to 1 m. in height. Leaves dull yellow green. Flowers light vermilion."

BOTANY.—*A new species of* Maurandia *from Death Valley.*[1] FREDERICK V. COVILLE and C. V. MORTON, U. S. NATIONAL HERBARIUM.

The genus *Maurandia* of the family Scrophulariaceae consists, according to the monograph[2] by Prof. P. A. Munz of Pomona College, of eight species, all natives of Mexico with the exception of *M. antirrhiniflora* H. & B., a peculiar species which has been shifted back and forth between *Maurandia* and *Antirrhinum* for many years. At the time of publication of this monograph *M. antirrhiniflora* was the only species known from the United States, but shortly thereafter a second species, *M. acerifolia*[3] Pennell, was described from Arizona. During the course of field work in Death Valley under the auspices of the National Geographic Society the senior author in company with Mr. M. French Gilman found a plant of this alliance which at first was considered to represent a new generic type, because of its one-celled ovaries and capsules. Later collections by Mr. Gilman have shown, however, that occasionally both cells of the ovary are fully developed and fertile. It has seemed best, therefore, to consider this plant, despite its peculiar characters, as a new species of *Maurandia*, although future studies may show that it is as distinct generically as *Epixiphium* and *Rhodochiton*, monotypic genera segregated from *Maurandia*.

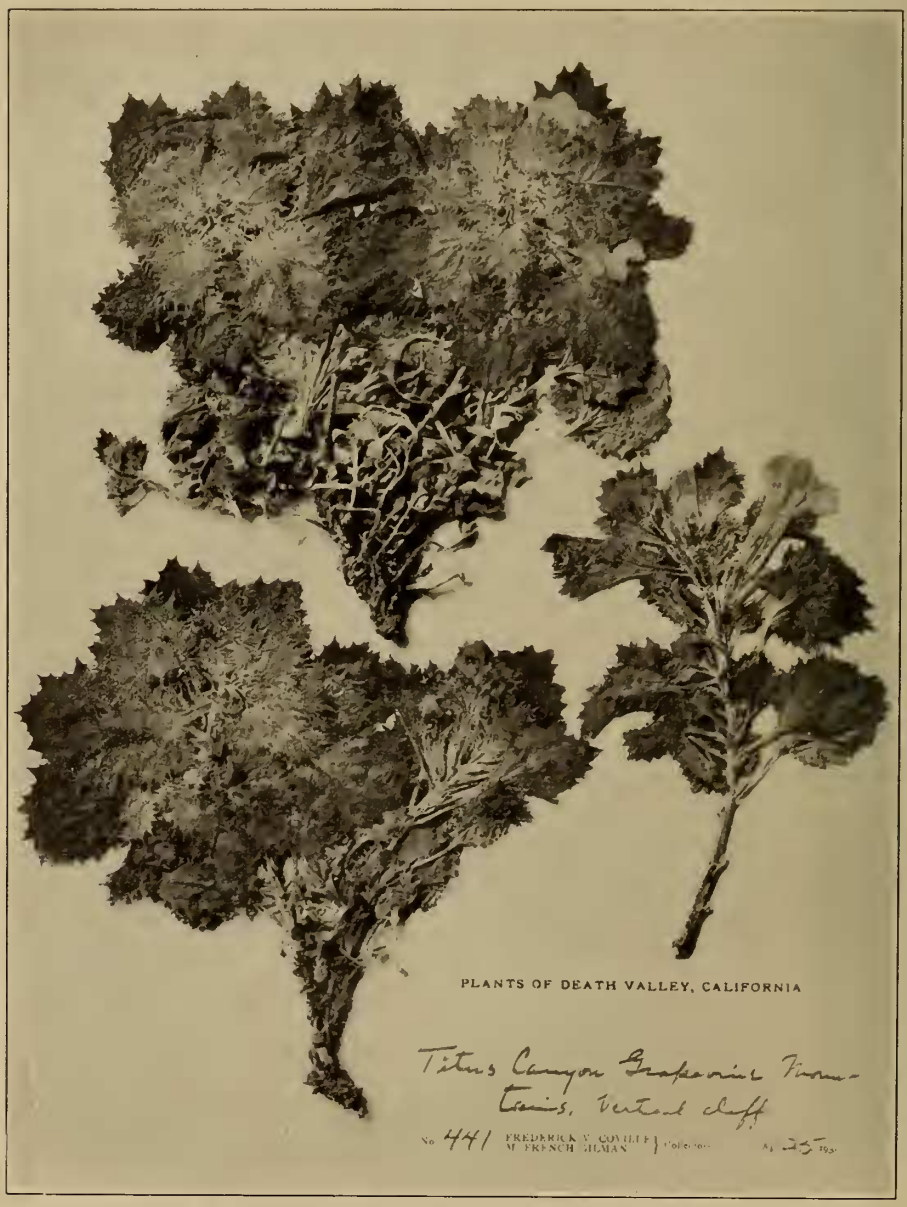
That our knowledge of the flora of the arid Southwest is as yet far from complete is well shown by the fact that the only yellow-flowered species of *Maurandia* known, viz., *M. flaviflora*, *M. acerifolia*, and *M. petrophila*, have all been discovered within the last few years. *M. petrophila* does not resemble the other two very closely.

The original specimens were growing in a crevice of the north-facing, vertical rock wall of Titus Canyon, composed at that point of a almost white limestone.

[1] Published by permission of the Secretary of the Smithsonian Institution. Received April 30, 1935.

[2] *The Antirrhinoideae-Antirrhineae of the New World.* Proc. Calif. Acad. Sci. IV. **15**: 323–397. 1926.

[3] This JOURNAL **19**: 69. 1929.



Maurandia petrophila Coville & Morton, sp. nov.
(Type specimen; about two-thirds natural size)

Maurandia petrophila Coville & Morton, sp. nov.

Section *Lophospermum*. Herba perennans, erecta, usque ad 17 cm. alta, basi ramosa; caules pallido-virides, ca. 2 mm. diametro, villosuli, pilis hyalinis articulatis eglandulosis, internodiis saepissime brevibus; folia alterna, petiolata, petiolis usque ad 3 cm. longis, villosulis, apice dilatatis; laminae

ambitu suborbiculares, usque ad 3 cm. longae et latae, membranaceae, pallido-virides, basi in petiolum attenuatae, apice rotundatae vel acutae, margine irregulariter et acriter spinuloso-dentatae, utrinque molliter villosulae; flores in axillis foliorum solitarii, pedicellati, pedicellis brevissimis; calycis segmenta fere libera, lineari-lanceolata, per anthesin usque ad 15 mm. longa et 2.5 mm. lata, acuminata, margine valde spinulosa, pallido-viridia, utrinque villosula; corolla lutea, tubulosa, usque ad 3.5 cm. longa, basi non saccata, tubo ca. 5 mm. lato, extus fere glabro vel apicem versus villosulo, intus glabro vel pilis paucis hyalinis praedito, sursum gradatim ampliato, fauce 7-9 mm. lato, plicis duobus aurantiacis vix puberulis instructo, lobis patentibus, magnis, usque 9 mm. longis, imbricatis, basi paullulum angustatis, apice late rotundatis, integris; stamina 4, didynama, inclusa, filamentis sparse stipitato-glandulosis, apice recurvatis, antheris semicircularibus, loculis explanatis, discretis, glabris; staminodium nullum; ovarium glabrum, ovoideum; stylus tenuis, glaber; discus hypogynus brevis, annularis; capsula sphaeroidea, ca. 9 mm. diametro, glabra, stylo peristente coronata, unilocularis (loculo altero abortivo, sterili) vel rarissime bilocularis, placenta magna intrusa persistente, irregulariter apice dehiscens, textura membranacea; semina numerosa, subpyramidalia, ca. 2.5 mm. longa, 2 mm. apice lata, pallido-flava vel cinerea, apice alulis brevissimis non nunquam transversalibus praedita, dense tuberculata, tuberculis spongiosis, in lineis irregularibus longitudinalibus dispositis.

Type in the U. S. National Herbarium, no. 1,565,465, collected in Titus Canyon, Grapevine Mountains, Death Valley, California, April 25, 1932, at 2100 feet elevation, by Frederick V. Coville and M. French Gilman (no. 441). Mr. Gilman has since collected this species at the type locality, on April 17 and April 29, 1934 (*Gilman* nos. 1108 and 1195 respectively).

The following key will serve to separate the present species from *M. acerifolia:*

Leaves conspicuously spinulose, suborbicular; pedicels very short; corolla up to 35 mm. long; calyx lobes linear-lanceolate, spinulose; seeds pale, about 2.5 mm. long. . . . . **M. petrophila.**

Leaves shallowly dentate or lobed, cordate or reniform; pedicels 10–20 mm. long; corolla up to 22 mm. long; calyx lobes triangular-ovate, entire; seeds gray or blackish, 1–1.5 mm. long. . . . . **M. acerifolia.**